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TECHNOLOGY TRANSFER PROGRAM (TTP)

FINAL REPORT

FACILITIES AND INDUSTRIAL ENGINEERING

FACILITIES and INDUSTRIAL ENGINEERING EXECUTIVE SUMMARY

91

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in conjunction with:
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PREFACE

This document is a summary of a report on Facilities and Industrial Engineering resulting from the Shipbuilding Technology Transfer Program performed by Livingston Shipbuilding Company (LSCo)under a cost-sharing contract with the U. S. Maritime Administration.

This summary provides a condensation of the findings and conclusions of Livingston's study of the practices currently in use in the shipyards of Ishikawajima-Harima Heavy Industries Co., Ltd., (IHI), of Japan. Livingston gratefully acknowledges the generous assistance of the IHI consulting personnel and of all the IHI personnel in Japan who made this study possible.

For details concerning the Technology Transfer Program or of the information contained herein, please refer to the full Final Report on this subject.

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INTRODUCTION

GENERAL

The purpose of this study was to evaluate the IHI facilities, systems, concepts and work methods as they are applied in a Japanese working environment.

Industrial Engineering activities are not performed by a centralized group at IHI. Most of the traditional Industrial Engineering work is performed by the Staff Groups composed of Field Engineers within each of the production workshops.

Livingston and IHI personnel jointly examined the Livingston facilities which were compared to the IHI facilities to determine the most significant differences between the shipyards and the areas that would benefit most from a change in layout, additional space, new equipment or other facility improvement. A long-range plan was developed for Livingston which incorporated the facility improvement plans emanating from these studies. Livingston's findings and conclusions resulting from the studies of facilities and methods are documented throughout this report.

A series of appendices are included in Volume II of this report as an adjunct to the findings and conclusions presented herein. These appendices comprise data provided by IHI in the course of this program. The appendices are listed below:

A. Significant Difference and Specific Production Areas by Y. Mikami; November 5, 1979

B. General View of LSCo, by T. Yamamoto; June 20, 1979

C. Method Improvement (Welding), by Y. Kawanaka; May, 1979 (Sections 2, 4, and 9)

D. Pipe Fabrication, by E. Yamamoto; June, 1979
PF-9 (List of IHI Equipment)
PF-39 Section II (Explanation of Pictures of Equipment)

E. Concept and Application of Pre-Outfitting, by S. Sato; October, 1980, pp. 1-12, 32-43, and 51-55

F. Ideal Approach for Mold Loft System in LSCo, by K. Honda; April, 1979 HP-080, HP-079

FACILITIES CAPABILITIES AND CAPACITY

A study was conducted in early 1979 to document Livingston facilities, capacities and throughput rates and to establish a baseline for future comparison.

IHI examined Livingston's facilities and made a number of proposals for improvements. After empirical analysis of these recommendations, the ones compatible with Livingston's growth objectives and budget constraints were selected for further analysis.

Following the analysis of Livingston's facilities and alternative facility changes is an IHI facility analysis which documents facilities at the IHI-Aioi shipyard in detail. A comparison analysis of IHI's and Livingston's facilities illustrates differences between the shipyards.

LSCo FACILITY STUDY

Livingston's facilities were documented in the Facility Capacity and Capability Study completed July 31, 1979 which documents LSCo'S facilities as they existed at the beginning of the Technology Transfer Program. The report measured throughout rates for the various facilities on the basis of production of a dry bulk carrier.

In general, the condition of the Levingston shipyard prior to implementation of the Technology Transfer Program can be characterized as follows:

1) The Facility Capability and Capacity Study summarized throughput rates for each area studied, as given below:

FACILITY	THROUGHPUT RATE
Outfitting:	
Pipe Shop	1.28 ships/year
Steel Areas:	
Shop 5 (N/C Machine)	1.40 ships/year
Transportation Equipment	1.80 ships/year
Assembly Areas: Fitters (Dept. 4)	1.79 ships/year
Assembly Areas: Welders (Dept. 6)	2.03 ships/year
Assembly Areas: Shop 5 (Dept. 5)	2.11 ships/year
Shop 6 (Current Panel Shop)	*1.98 ships/year
Shot Blast and Paint	2.00 ships/year
Sandblast and Paint	2.72 ships/year
Steel Storage	4.20 ships/year

*Current panel shop capacity was based only on construction of midship panel sections (Zone 1) due to efficiency, space and equipment limitations. Therefore, this figure actually represented midship sections per year. Additional capacity would permit construction of additional zones, including the deck house panels.

The above data indicated the constraining areas to be the N/C machine in Shop 5 for steel construction and the pipe shop in outfitting.

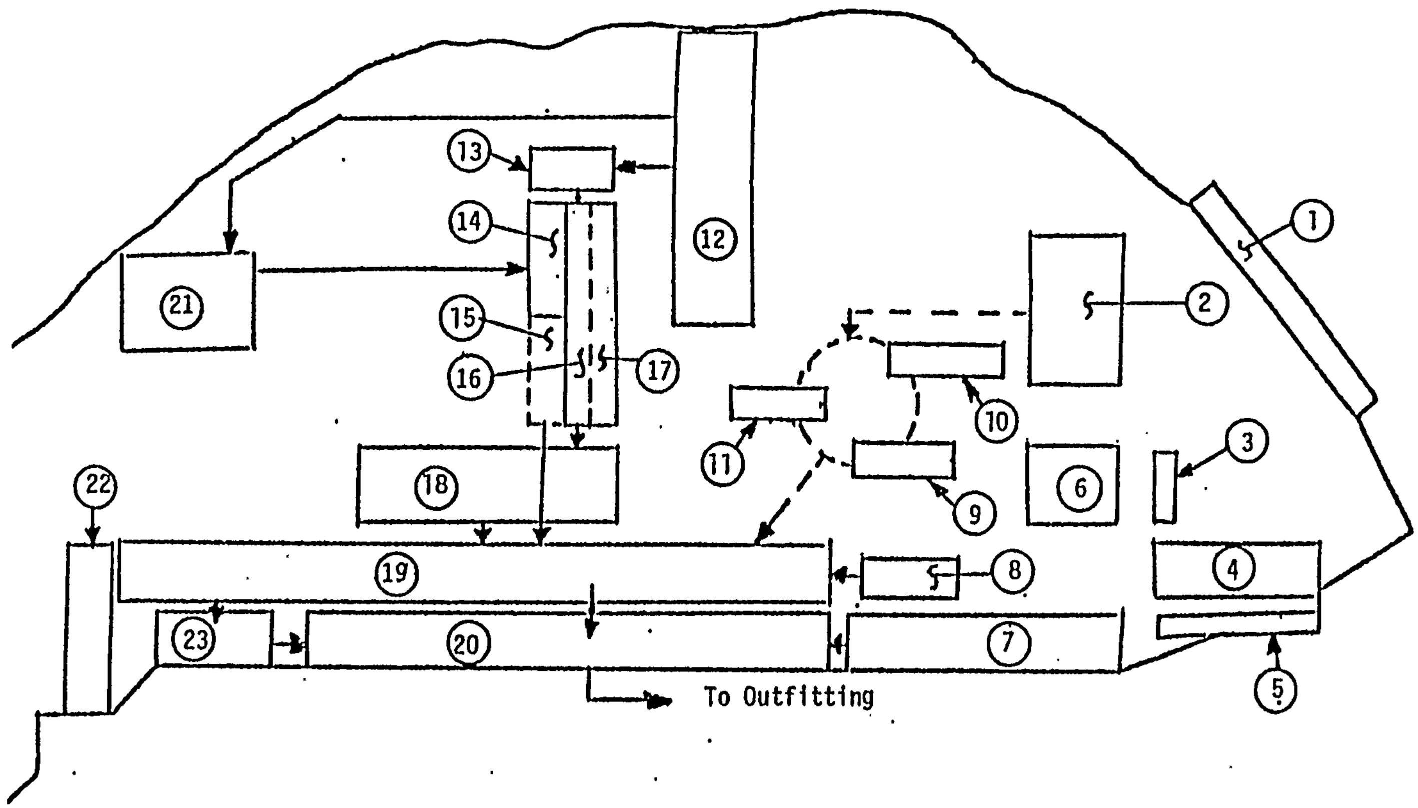
2) Units were fabricated and assembled on slab areas where space was available with no central planning of unit placement. Units were built where a location could be found. Space was not used to maximum effectiveness, nor was there an overall plan for an orderly flow of materials from fabrication to erection sites.

   Figure 1-1, the LSCo layout prior to TTP, shows a general view of the facility layout and material flow. Figure 1-2 shows how the Gate System has been applied to the existing facilities arrangement.

3) Insufficient-and inadequate slab facilities were in existence.

4) No covered panel line was in existence.

1. OUTFITTING
2. WHSE & REC'G
3. ELECT.
4. ASSEMBLY
5. OUTFITTING
6. SUB-ASSEMBLY
7. ASSEMBLY
8. FAB SHOP
9. PIPE SHOP
10. MAINTENANCE SHOP
11. CARPENTER SHOP
12. STORAGE
13. SHOT BLAST
14. PANEL
15. SHOP
16. PLATE FAB
17. LONG'L FAB
18. SUB-ASSEMBLY
19. SUB-ASSY & ASSEMBLY
20. ERECTION/SIDE-LAUNCH
21. SAND BLAST
22. END LAUNCH
23. ASSEMBLY



GENERAL FLOW OF MATERIALS AT LEVINGSTON

FIGURE 1-1

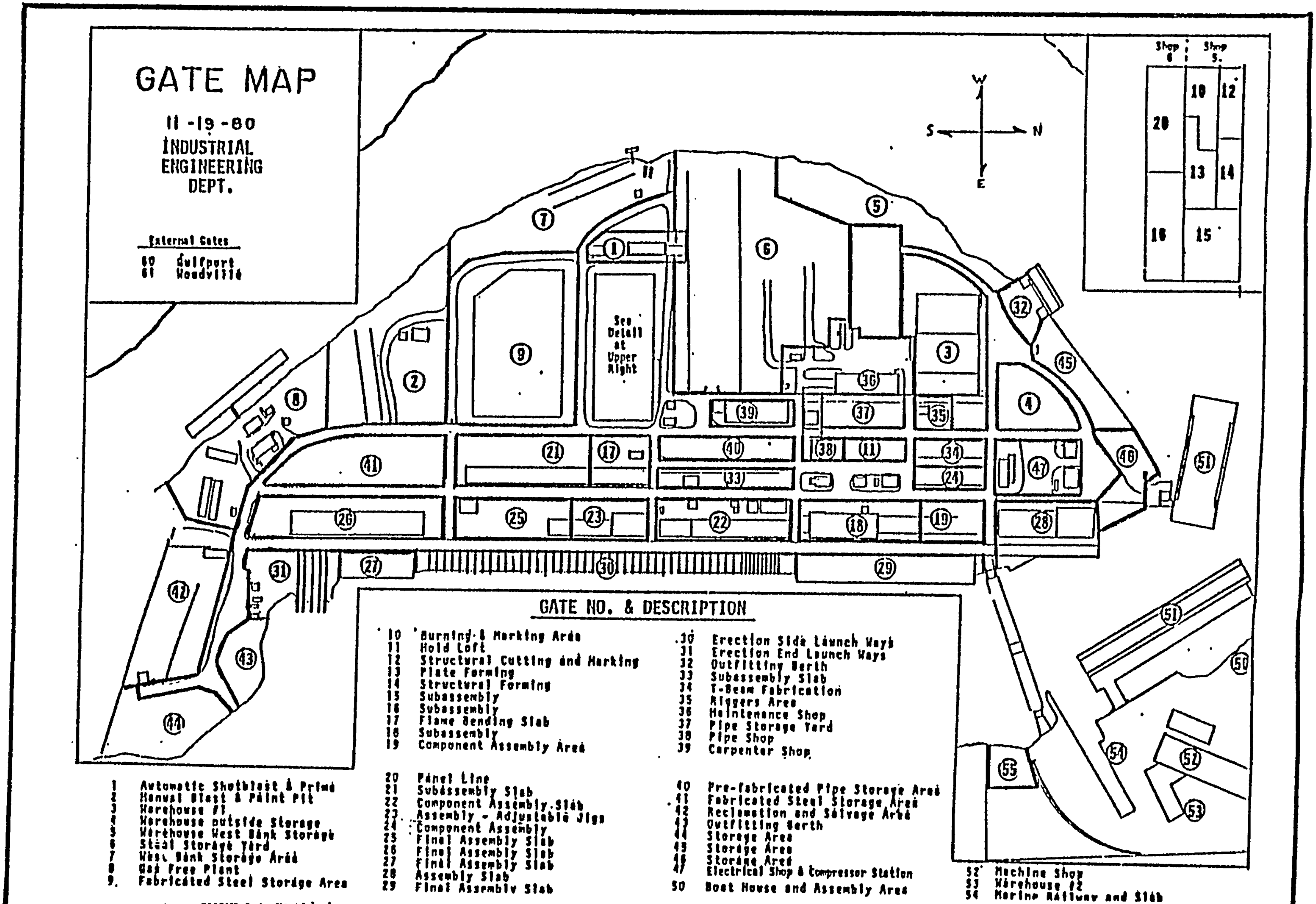

GATE MAP
11-19-80
INDUSTRIAL ENGINEERING DEPT.
External Gates
60 Gulfport
61 Woodville
See Detail at Upper Right
Shop 6
Shop 5
W
S
N
E
GATE NO. & DESCRIPTION
1 Automatic Shotblast & Prime
2 Manual Blast & Paint Pit
3 Warehouse #1
4 Warehouse outside Storage
5 Warehouse West Bank Storage
6 Steel Storage Yard
7 West Bank Storage Area
8 Gas Free Plant
9. Fabricated Steel Storage Area
10 Burning & Marking Area
11 Mold Loft
12 Structural Cutting and Marking
13 Plate Forming
14 Structural Forming
15 Subassembly
16 Subassembly
17 Flame Bending Slab
18 Subassembly
19 Component Assembly Area
20 Panel Line
21 Subassembly Slab
22 Component Assembly Slab
23 Assembly - Adjustable Jigs
24 Component Assembly
25 Final Assembly Slab
26 Final Assembly Slab
27 Final Assembly Slab
28 Assembly Slab
29 Final Assembly Slab
30 Erection Side Launch Ways
31 Erection End Launch Ways
32 Outfitting Berth
33 Subassembly Slab
34 T-Beam Fabrication
35 Riggers Area
36 Maintenance Shop
37 Pipe Storage Yard
38 Pipe Shop
39 Carpenter Shop
40 Pre-fabricated Pipe Storage Area
41 Fabricated Steel Storage Area
42 Reclamation and Salvage Area
43 Outfitting Berth
44 Storage Area
45 Storage Area
46 Storage Area
47 Electrical Shop & Compressor Station
50 Boat House and Assembly Area
52 Machine Shop
53 Warehouse #2
54 Marine Railway and Slab

FIGURE 1-2

5) Shop layouts were not planned in an orderly fashion and consequently not conducive to efficient material processing resulting in substantial delays for craftsmen and material handling equipment and poor utilization of area for material storage and buffer storage.

6) Outfitting work was performed almost exclusively on-board. No pre-outfitting or modular outfitting was attempted.

IHI PRODUCTION IMPROVEMENT SUGGESTIONS

IHI proposed the following improvements in the areas listed:

Mold Loft: Purchase N/C drafting machine.

Fabrication and Sub-assembly: Line marking rather than punch marking on the N/C burning machine; Increased size and plate turning capability on presses in Shop 5; Clearly defined sub-assembly line in a specific area.

Assembly: Panel line installation;
Adjustable curved unit assembly jigs;
Auxiliary lifting equipment on cranes.

Erection: Crane capacity limits size of units that can be built at LSCo;
Use higher ratio of automatic and semi-automatic welding methods;
Moveable scaffold units are more effective than conventional scaffolding.

General: Effective utilization of various jigs at every stage.

COMPARISON ANALYSIS

It is difficult, and not particularly meaningful, to make a simple comparison of overall facilities between the IHI and Livingston shipyards. Therefore, this report relates specific facility areas that IHI felt could most effectively benefit Livingston and other medium size U. S. shipyards in allocating available capital resources.

A major difference is that the IHI facilities are basically built into an assembly line operation in order to maximize throughput of any given machine or piece of equipment. Each operation is scheduled to deliver a specific quantity of product within a given period and depends on the preceding operation for prompt and continuous delivery. At Livingston the method of operation results from the philosophy of fabricating, assembling and erecting pieces as individually needed results in only short-term (or non-existent) facility planning, uneven work flow, inefficient use of equipment, and on-the-spot decision making.

To summarize the facilities listed in this report which underwent comparison and study, Figures 1-3 and 1-4 are provided.

IHI FACILITY ANALYSIS AND COMPARISON

For purposes of analysis and comparison, the IHI shipyard in the city of Aioi was selected because of its similarity in size to Livingston and other medium size U. S. shipyards. The Aioi yard is very well equipped with facilities and technologies found in few U. S. yards of comparable size.

The productivity of the Aioi shipyard is consistently high. Total production is currently at 6,000 metric tons per month with a total employment of about 2,700. During the shipbuilding boom these figures peaked at 12,000 tons per month and an employee complement of 4,000. These figures do not include employment and production from the large group of subcontractors which are also heavily involved with the IHI yards.

Figure 1-5 provides an overall view of the layout and material flow in the Aioi yard.

SUMMARY OF FACILITY COMPARISONS

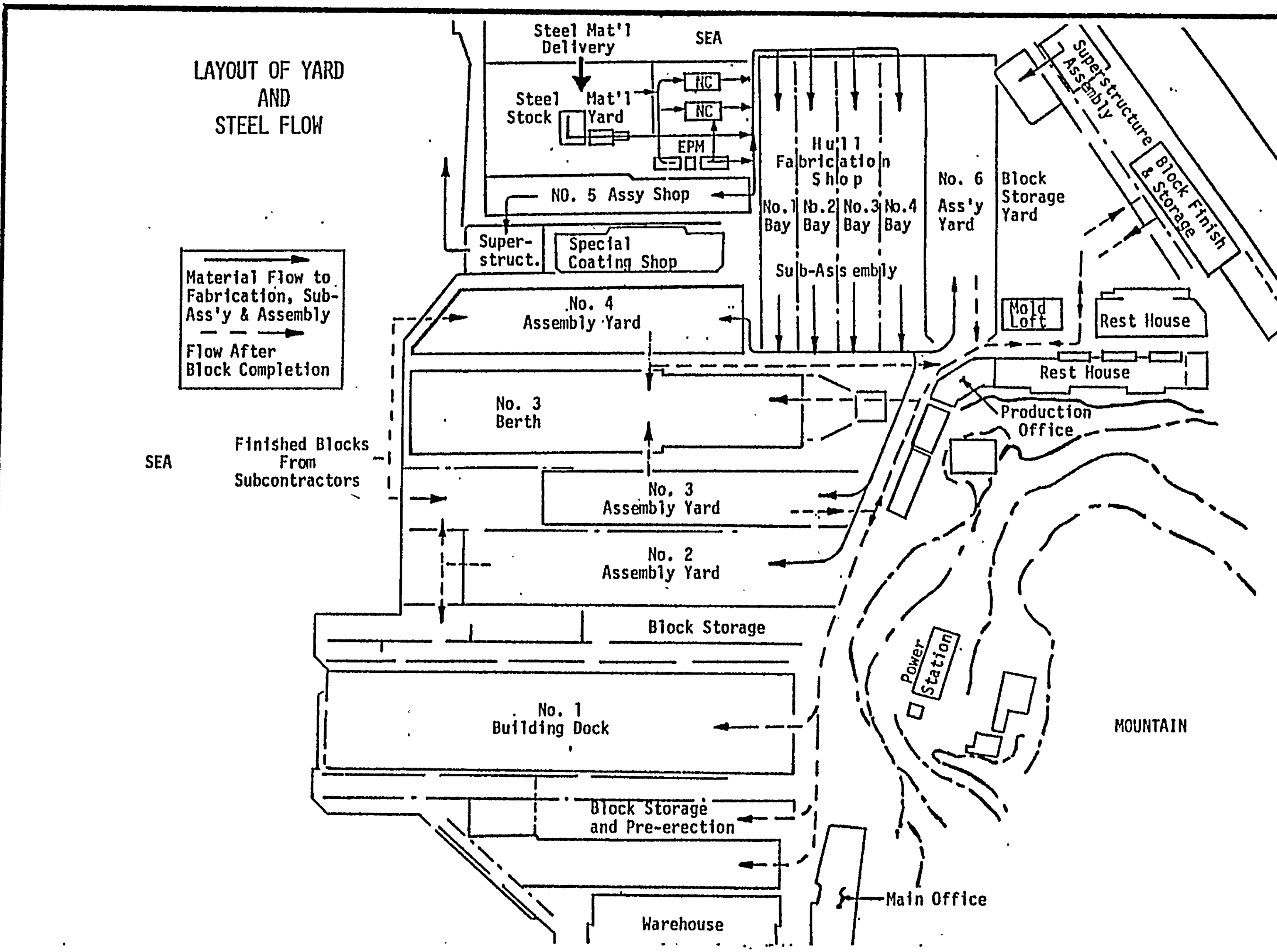
FACILITY	IHI-AIOI	LIVINGSTON
1. Mold Loft	a) 1/10 Scale Drafting machine b) EPM system enlarges image to full size using precision optical projector	a) None b) None
2. Fabrication & Sub-assembly	a) 3 N/C burners (AIOI)=6,000-8,000 tons/mo. Cuts plates requiring high precision and repetition Line marking system b) Forms pieces by flame bending after machine bending c) 2 Web assembly areas: 1) straight line 2) special webs	a) 1 N/C burner=l,500-1,800 tons/mo. Cuts variety of plates Punch marking system b) Forms by mechanical means only c) No specified sub-assembly area for web frames, etc.
3. Assembly	a) **2 "flat plate" panel lines** b) **Adjustable curved unit assembly jigs ("pin" jigs)** c) **Assembly areas assigned for a unit according to pre-planned flow**	a) Panels assembled on slabs b) Permanent, fixed-type jigs c) Assembly in available spaces determined by Production Superintendent
4. Erection & General	a) Portable scaffolding b) Units constructed in positions allowing high utilization of auto and semi-auto welding including one-sided welding	a) Conventional scaffolding b) Welding method prescribed by construction method. No one-sided welding
5. Outfitting	a) Pipe mass-produced in shop b) Pipe bending utilized c) High pre-outfitting, modular outfitting d) Pallets used extensively to transport materials	a) Pipe fabricated at erection site b) No auto bending- use fittings c) No pre-outfitting d) No palletization system

FIGURE 1-3

	FACILITIES STUDY	PURPOSE OF STUDY	EXISTING CONDITION	DESIRED RESULT
1• Mold Loft	-H/C Drafting machine	-To determine if machine could increase loft output, decrease loft time and improve cutting accuracy.	-Every new drawing or revision to a curved section must go through a manual drafting process. -Large scale templates and models are required in the mold loft.	-Decrease engineering time an estimated 15-20x of a manhours/contract. -Decrease mold loft manhours, estimated at 50I of manhours/contract.
II. Fabrication & Sub-assembly	-H/C Cutting machine	-To improve accuracy of cutting, utilization of the N/C cutter, and to increase output.	-inaccurate cutting, causing adjustment or repair. -Too much reliance (n H/C for detail parts. -Cutting speed - 14 In/min.	-Better accuracy -Full utlization or major cutting. -Cutting speed l 85 In/mIn.
	-Optical tracing machine	-Can it increase effective use of N/C burner by cutting detail parts?	-H/C machine cuts all size parts.	-Use N/C machine for major cutting, optical tracing machine for detail parts.
	-Flame bending	-Determine application of flame **bending to forming shpaes.**	-Presses & rolls used for forming.	-Use of flame bending technique in a separate area to supplement forming operation by machine,
III. Assembly	-Panel Line	-Determine savings with panel production in covered area, assembly line fashion.	-Panels produced on outside slab areas.	-Increased throughput by enclosing the panel operation & establishing mechanized flow process.
	-Assembly Jigs	-Review application of adjustable Jig.	-Use of fixed jigs, useful only for one unit.	-Use an adjustable Jig to have application to all variable size jigs.
IV. Erection & General	-Scaffolding	-Compare cost of renting, building or buying scaffolding,	-Much scaffolding is rented, remainder is built.	-Duy scaffolding if it is economical.
	-Welding	-Review welding equipment & welding processes for Improvements.	-Only two-sided welding in affect. -No thought given to buiId units with the intent of utilizing the most effective welding technique.	-Implement one-sided welding whenever possible, -Plan construction of units with welding procedure in mind.
V, Outfitting	-Pipe shop	-Study improvements to be gained through larger area, improved layout and better pipe fabrication system.	-Pipe shop not designed for large scale production-pipe fabrication performed at erection site.	-Efficient pipe fabrication and handling.
	-Pipe bender	-Determine use of automatic pipe **bender.**	-Curves in pipe achieved by cutttng pipe & using ells & fittings.	-Bend pipe to eliminate use of fittings & save labor.
	-Palletization	-Determine savings by using pallets to transport materials,	-Materials transported individually by mobile crane. or on standard-size skids.	-Transport material in groups or pallets.

SUMMARY OF LSCo FACILITY STUDIES

FIGURE 1-4



IHI AIOI SHIPYARD

FIGURE 1-5

LSCo/IHI AIOI FACILITIES COMPARISON

A detailed comparison between IHI's Aioi shipyard and Livingston has been undertaken to show the IHI facilities at Aioi in contrast with Livingston, first near the beginning of the Technology Transfer Program in February, 1979, and again in April of 1980 at the end of the facilities study conducted under TTP Sub-task 4.1. The results of these comparisons are shown in the following data:

IHI - LSCo FACILITY COMPARISON

(Area - Ft^2)

Name	IHI	LSCo (2/79)*	LSCo (4/80)
Steel Storage			
Plates	37,700	90,000	131,000
Structural	17,500	55,000	102,000
Total	55,200	145,000	233,000
Covered	-0-	-0-	-0-
Fabrication Areas			
Shotblast and paint	9,500	6,400	6,400
Marking	17,500	5,200	8,950
N/C Cutting	29,600	4,400	7,650
Manual cutting - plate	30,400	6,000	5,250
Manual cutting -structurals	5,300	6,000	6,000
Flame planer	8,400	3,200	1,950
Plate bending	17,750	10,450	21,400
Flame bending	17,750	6,000	6,000
Storage -fab. pieces	16,900	4,700	74,250
Sub-assy - flat pieces	48,000	10,000	24,400
Sub-assy - curved pieces	30,600	45,200	49,700
Total	231,700	107,550	211,950
Covered	231,700	62,300	64,250
Assembly Areas			
Panel line(s)	128,400	33,200	35,600
Flat panel-unit (assy & stg)	118,000	67,200	103,400
Curved unit (assy & stg)	72,800	14,800	14,800
Cubic unit (assy & stg)	65,200	16,600	16,600
Superstructure (assy & stg)	45,200	58,400	58,400
Pre-erection (unit-to-unit)	40,500	12,800	12,800
Total	470,100	203,000	241,600
Covered	318,800	8,200	15,600

Name	IHI		LSCo (2/79)*		LSCo (4/80)
Erection (Launchways)	188,200	(end)	94,000	(side)	94,000
	142,000	(end)	17,100	(end)	17,100
Outfitting (areas not included above)					
Module assembly	34,000				5,000
On-unit outfitting area	111,400		**		**
On-board outfitting wharf	64,350		6,000		6,000
Superstructure outfitting	37,200		**		**
Painting area	23,700		93,000		124,200
Pipe shop	59,500		8,400		8,400
Fabricated pipe storage	25,500		3,000		24,000
Misc. assembly - O/F	28,700		**		**
Deck outfitting	2,150		**		**
Accom. O/F and preparation	1,500		**		**
Machine shop	11,000		16,000		16,000
Propeller & shaft work area	1,600				
Painting workshop	2,650				
Other outfitting	11,250				
Total	414,500		126,400		183,600
Covered	145,700		24,400		24,400
Warehousing & Supplies					
Stock part warehouse	41,000		36,000		36,000
Small mach/accom supplies	39,000		77,000		128,500
Elect workshop & supplies	9,700		2,000		2,000
Oils and paints	27,700		1,600		1,600
Raw pipe, mist O/F steel	58,100		25,600		37,600
Scrap materials	14.000		40,000		40,000
Other	24,550				13,000
Total	214,050		182,200		258,700
Covered	137,850		39,600		50,100
Total Ground Area (including Repair, etc.)	6,832,965		5,235,200		5,235,200
Total Utilized Area	1,715,750		875,250		1,239,950
Total Covered Area	834,050		134,500		154,350

NOTES:

*Some data of individual process areas for LSCo on 2/79 are estimated where specific sites were not designated.

**LSCo outfitting areas are included as "assembly areas". IHI has some areas designated specifically for outfitting work, in addition to the fabrication and assembly areas where outfitting is also done.

IHI

Types of ships built:	Bulk Carrier Product Carrier Tanker Container Ship

Building	No. 1 Building Dock	No. 3 Building berth
	291.5m length 60m breadth 12m depth 95,000 gross tons 180,000 deadweight tons	287m length 46m breadth 91,000 gross tons 164,000 deadweight tons

Quays:	Length	Depth
No. 1	240m	6m
No. 2	99m	5m
No. 4	250m	6m
No. 7	169m	8m
No. 8	169m	6m
No. 9	100m	7m
No. 10	100m	5m
No. 11	200m	6m
No. 12	340m	9m

The most significant improvements at Livingston during the Technology Transfer Program were in the following areas:

Area	Additional Amount	Main Improvement
Steel Storage	88,000 ft^2	Better arrangement, especially for storage of structural and for steel remnants.
Fabrication Areas	104,400 ft^2	Allocated space for flame bending process. Added designated space for fabricated steel storage. Improved utilization of shop space for sub-assembly.

Area	Additional Amount	Main Improvement
Assembly Areas	38,600 ft^2	Expanded steel fabrication shop to enclose panel line operations.
Outfitting Areas	57,200 ft^2	Added space for module assembly, fabricated pipe storage, and for painting of unit assemblies.
Warehousing	76,500 ft^2	Added space for storing supplies (covered building) and for raw pipe storage in racks.

A clearly significant portion of the IHI facility is covered. This provides the obvious benefits of stabilized production due to less dependence on weather factors, and allows easier compliance with the strict national pollution standards.

A percentage comparison of covered areas by each production stage, between current IHI and LSCo facilities is as follows:

Area	IHI	LSCo
1. Steel storage	0%	0%
2. Fabrication	100%	30%
3. Assembly	65%	6%
4. Launchways	0%	0%
5. Outfitting	35%	13%
6. Warehousing	65%	19%
Total (excluding 1 and 4)	62%	17%
Grand Total	49%	12%

PRODUCTION METHODS

The methods specifically covered in this section include: marking and cutting, panel line assembly, sand/shot blasting, zone outfitting including pre-outfitting and palletization, welding, and jigs and fixtures.

HULL CONSTRUCTION

The methods used in hull construction cover the range of processes from the mold loft to the erection stage. Process flow charts provided by IHI to describe these processes are shown on the following pages as Figures 1-6 through 1-12.

These processes are briefly explained as follows:

Mold Loft

The mold loft work is classified into three categories:

1) Panel
2) Longitudinal Frame
3) Internal Member
   a) EPM Process
   b) NC Process

Fabrication

The fabrication process is classified into four categories:

1) Panel
2) Internal Member
3) Angle
4) Built-up Longitudinal

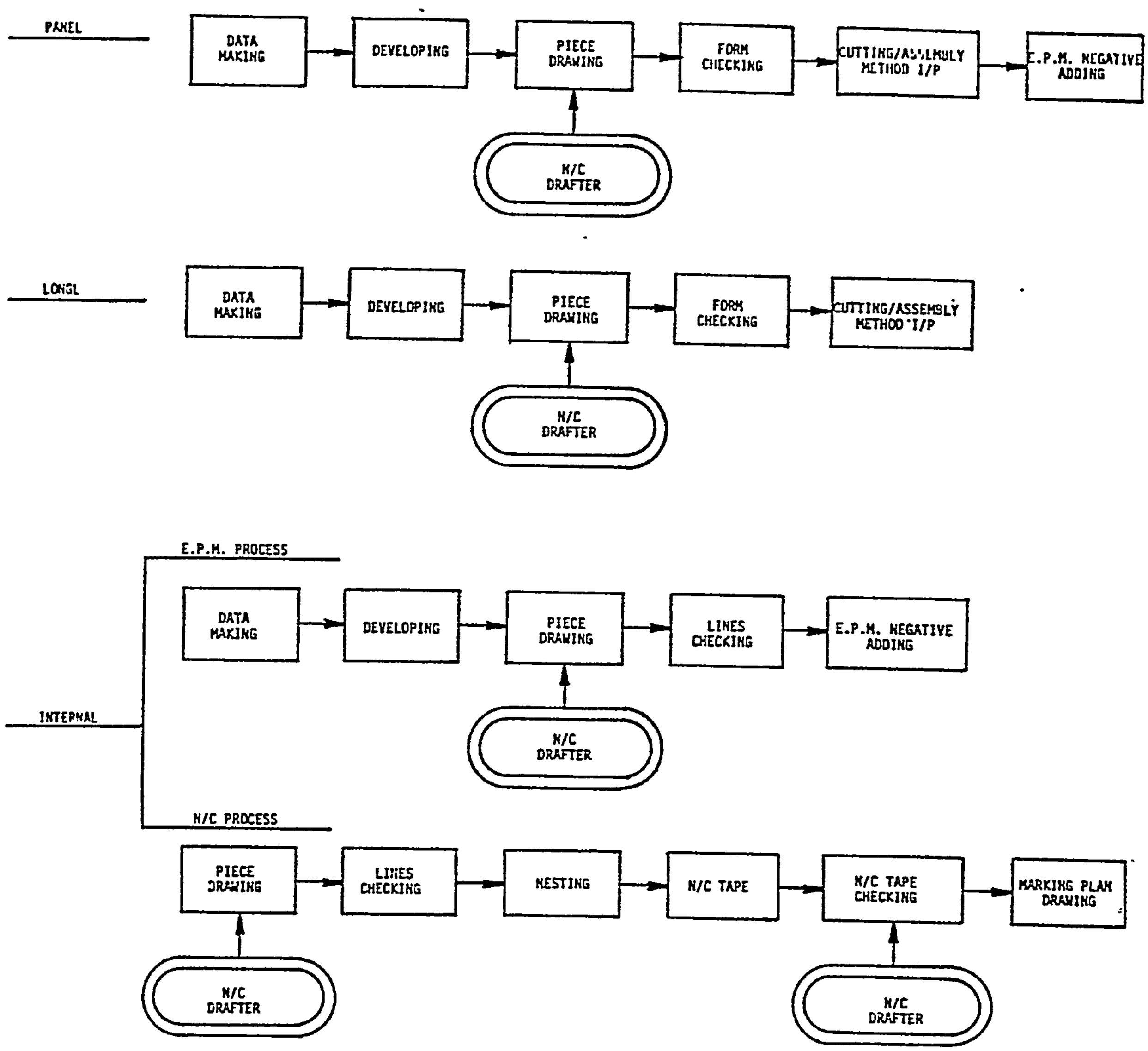
Sub-Assembly

Approximately one-third of the total assembly weight is produced at the sub-assembly stage in advance of the start of assembly work.

Assembly

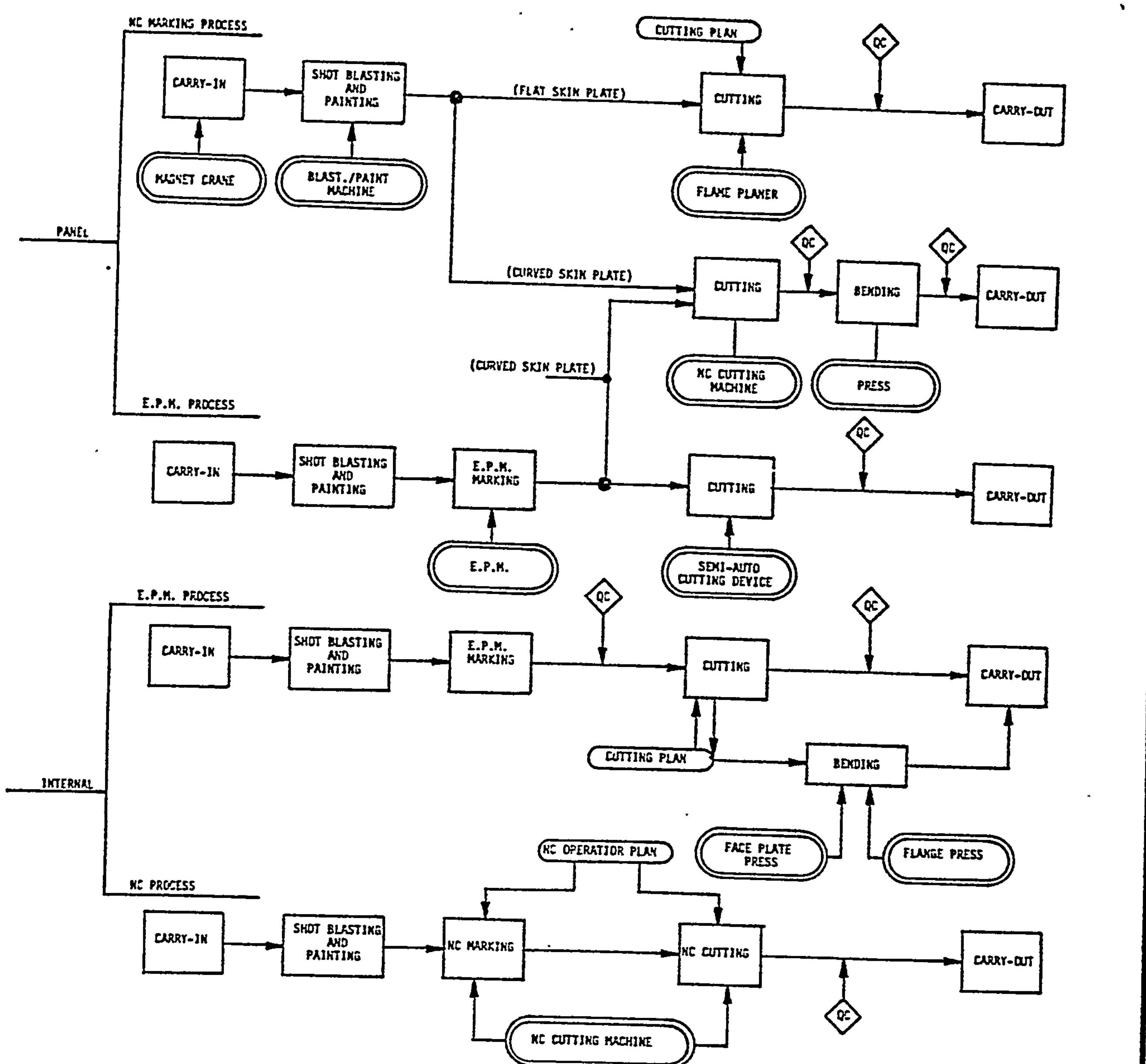
Assembly work is classified into three categories:

1) Panel Unit
2) Semi-Panel Unit
3) Curved Panel Unit



FLOW CHART OF MOLD LOFTING

FIGURE 1-6



FLOW CHART OF FABRICATION (1/2)

FIGURE 1-7

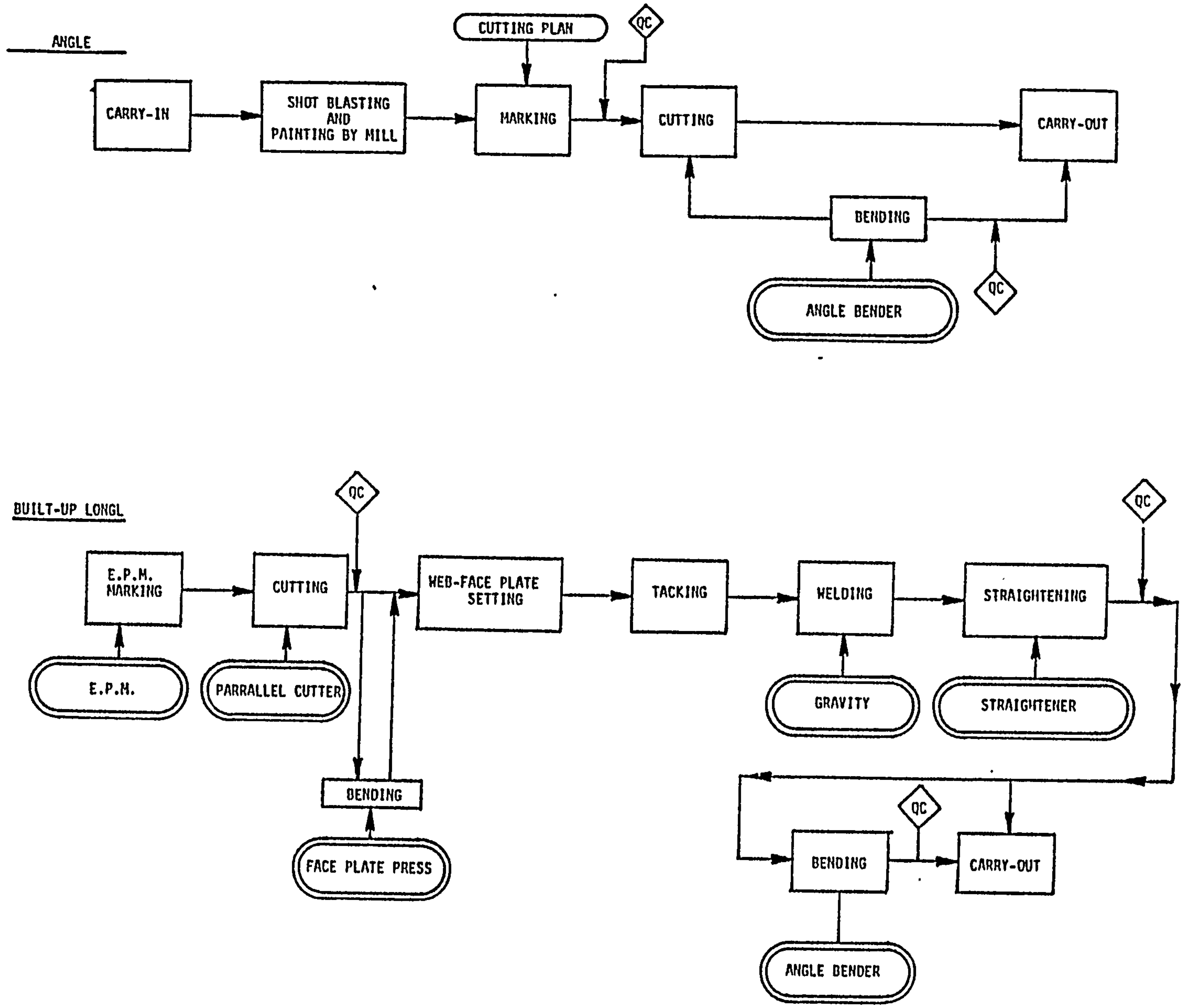
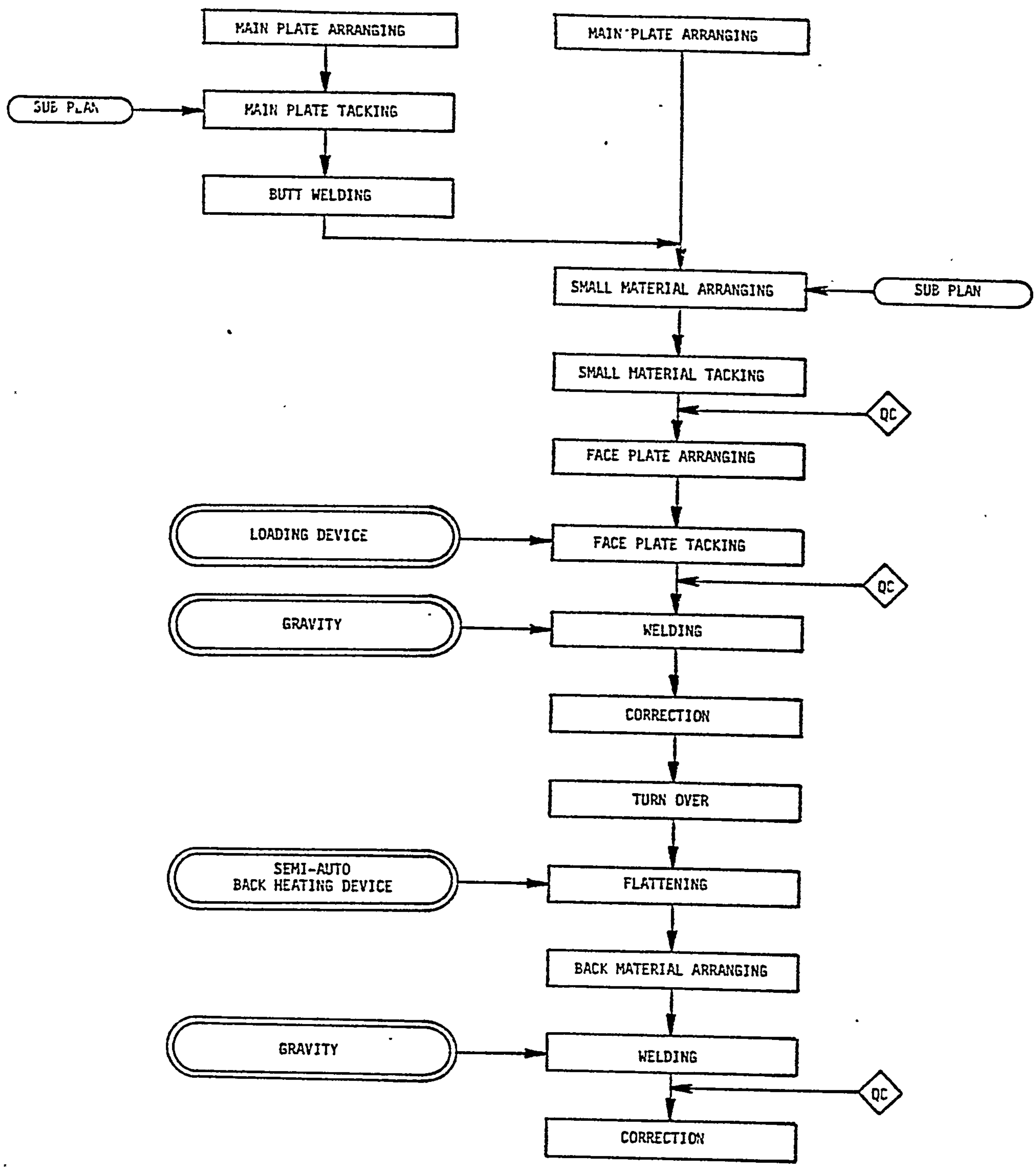
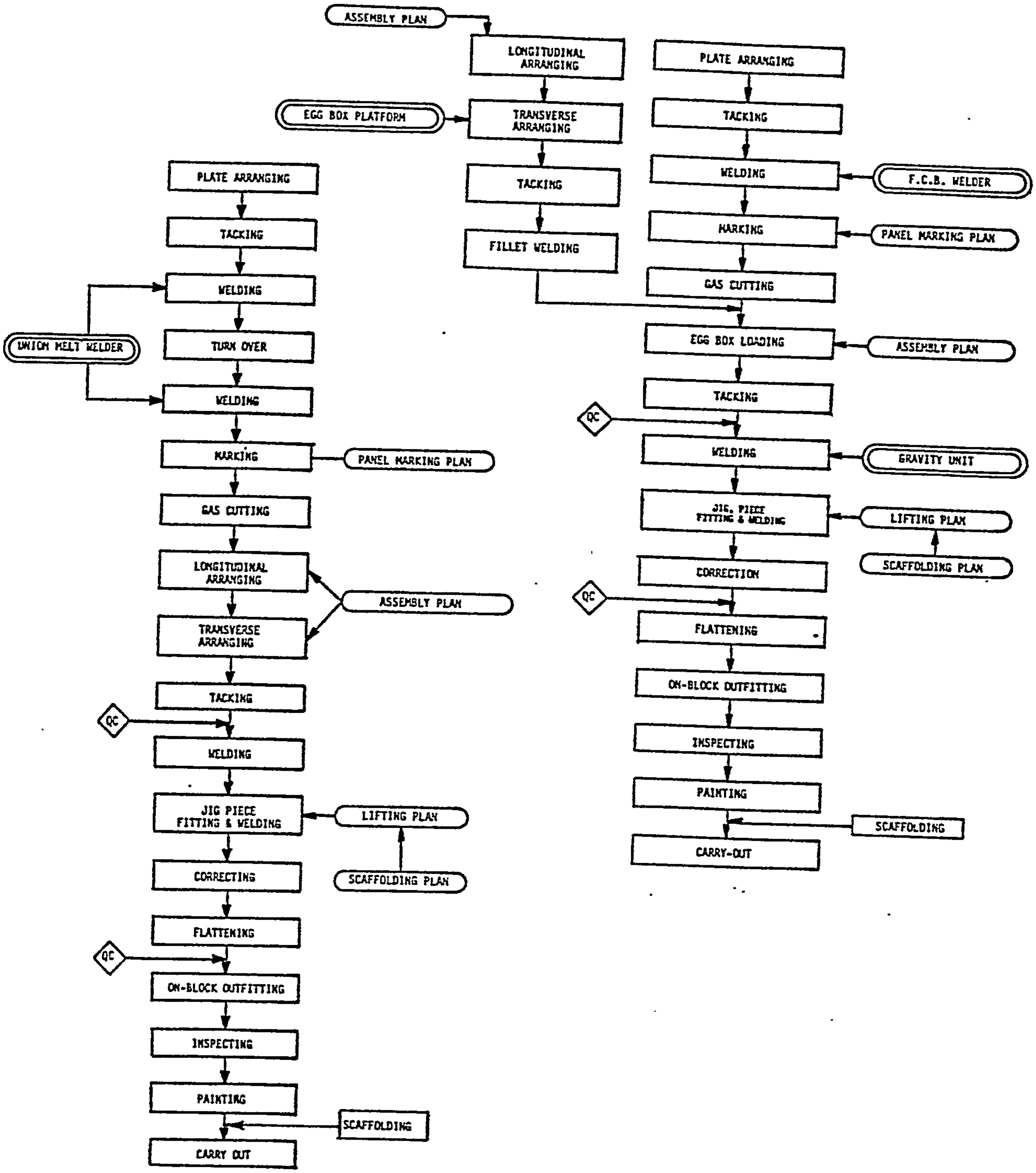


FIGURE 1-8 FLOW CHART OF FABRICATION (2/2)



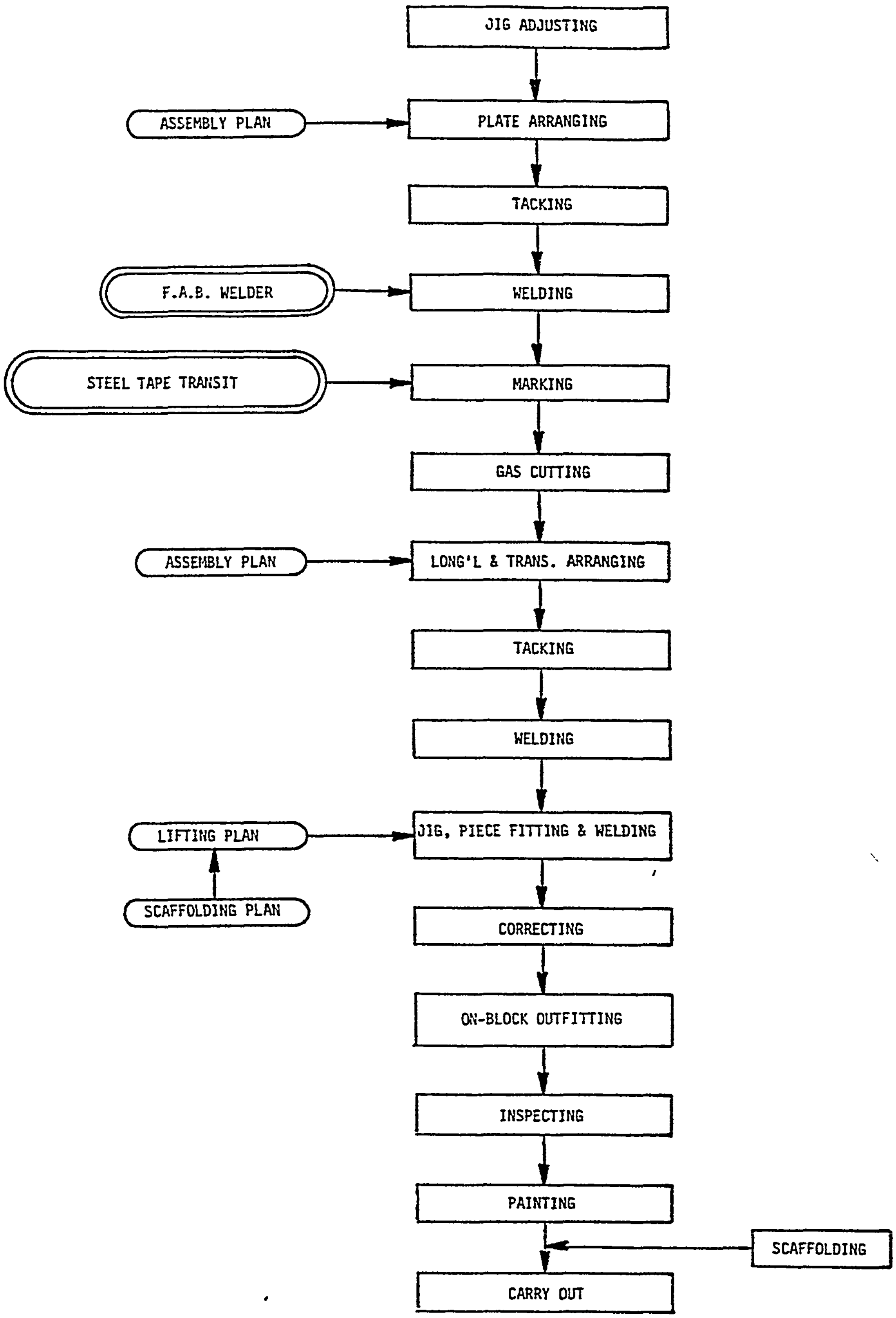
FLOW CHART OF SUBASSEMBLY

FIGURE 1-9



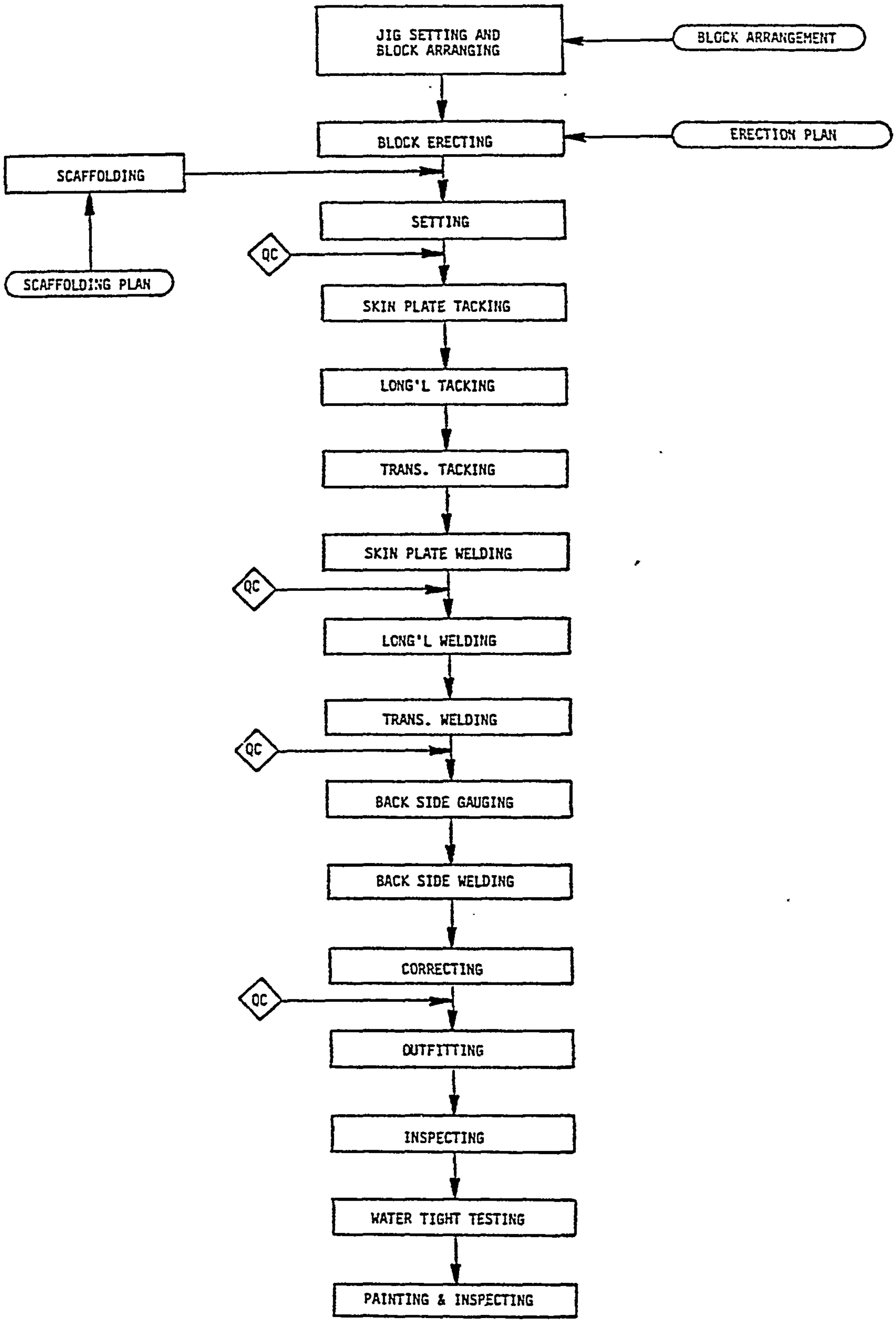
FLOW CHART OF FLAT PANEL ASSEMBLY

FIGURE 1-10



FLOW CHART OF CURVED PANEL ASSEMBLY

FIGURE 1-11



FLOW CHART OF ERECTION

FIGURE 1-12

Erection

Erection work flow is described from the jig arrangement to the final paint and inspection step.

Marking and Cutting

The relationship of the marking and cutting functions to the mold loft and to production is shown in Figure 1-13. This chart illustrates the difference between the IHI and Livingston systems.

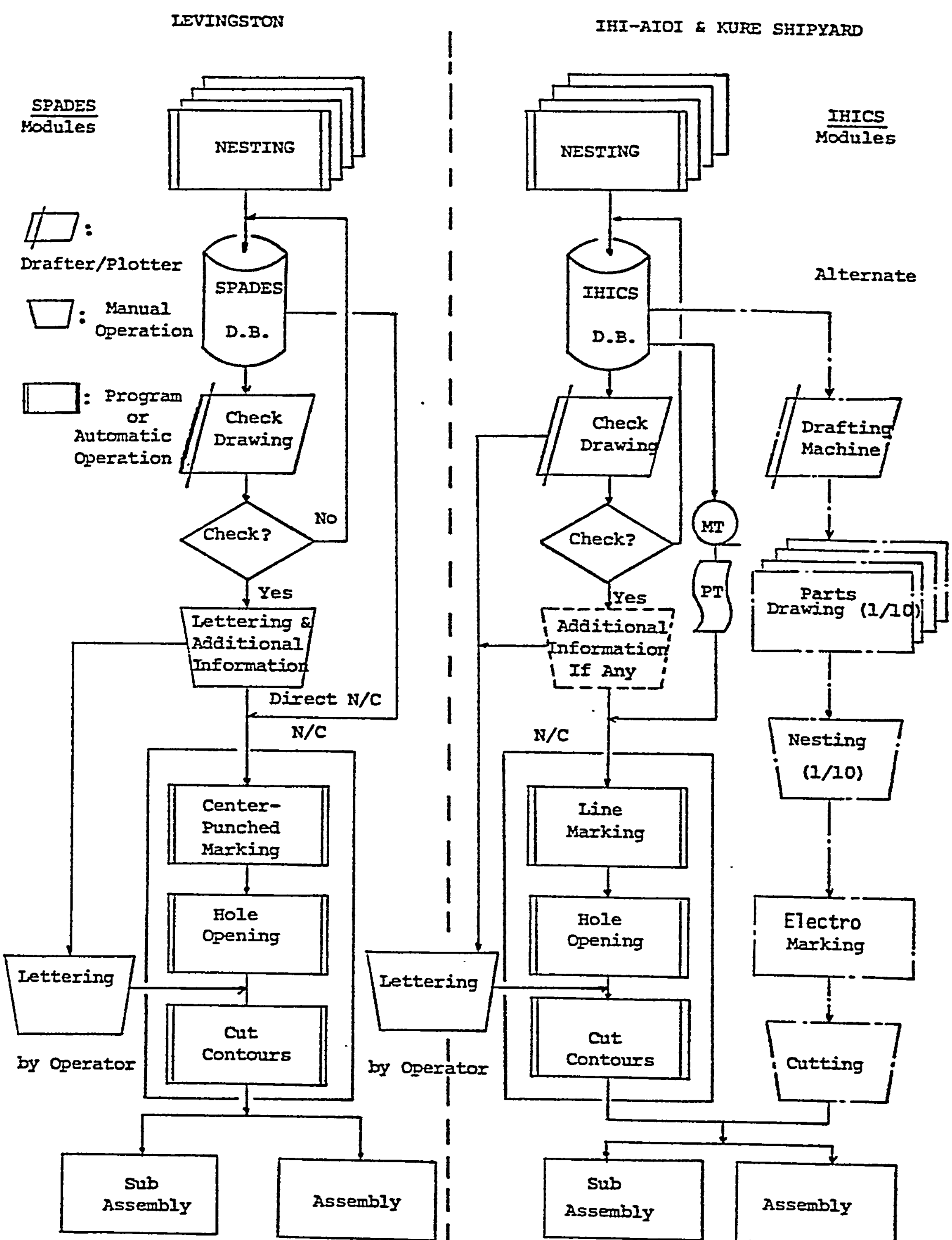
The choice of cutting machine for various component parts is shown in Table T1-1, which compares Livingston and IHI methods. A **comparison** of equipment available at Livingston and at the combined lHI facilities is shown in Table T1-2.

IHI’s recommendations regarding cutting methods are given in Table T1-3. Livingston reviewed its utilization of cutting machines as a result of the lHI proposals. The N/C burner is now scheduled to cut complex and repetitive pieces requiring high precision. The 1:1 Optical Tracing Unit cuts small, repetitive pieces. The flame planer is used to rip flanges and web frames. The material flow arrangement for the N/C machine recommended by IHI at Levimgston is shown in Figure 1-14. This layout and fabrication process is based on the assumption that the N/C machine would produce all cut plate except small pieces such as brackets, ribs, etc.

Panel Line

IHI has two “flat plate” panel lines located within the No. 2 and No. 3 Assembly Shops. Lay out and material flow patterns within these shops is illustrated in Figure 1-15.

The decision to build an enclosed panel line facility at Livingston was made prior to the arrival of IHI consultants.



COMPARISON OF N/C WORKS FLOW

FIGURE 1-13

TABLE T1-1

OBJECTIVE HULL PIECES FOR N/C MACHINE

Objective Pieces \ Company	LEVINGSTON	IHI-AIOI SHIPYARD (F-32)
WEB PLATE (HOLD)	N/C BURNING	N/C BURNING 117 PLT
FLOOR PLATE (HOLD)		
MAIN GIRDER		
WEB PLATE (OTHERS) FLOOR PLATE (OTHERS) GIRDER (OTHERS) BKT		N/C DRAWING ↓ Electro Marking ↓ HAND CUTTING 622 PLT*
CURVED SHELL		N/C BURNING 240 PLT
FLAT SHELL FLAT DECK FLAT WALL FLAT BULKHEAD		FLAME PLANER 606 PLT
FLAT BAR FACE PLATE	MATERIAL CUTTING LIST ↓ HAND MARKING ↓ HAND CUTTING	N/C DRAWING Electro Marking HAND CUTTING *Included Above *
FLAT SHAPE		MATERIAL CUTTING LIST HAND MARKING 1900 P HAND CUTTING
CURVED SHAPE		
COLLAR PLATE, ETC.	SHEARING OR N/C BURNING OR HAND CUTTING	MAGNET TRACER OR PHOTO TRACER

1) Numbers in IHI's columns are the actual numbers of plates for a "Future-32" constructed at IHI AIOI Shipyard.

TABLE T1-2

COMPARISON TABLE OF N/C BURNING MACHINE BETWEEN LSCo & IHI

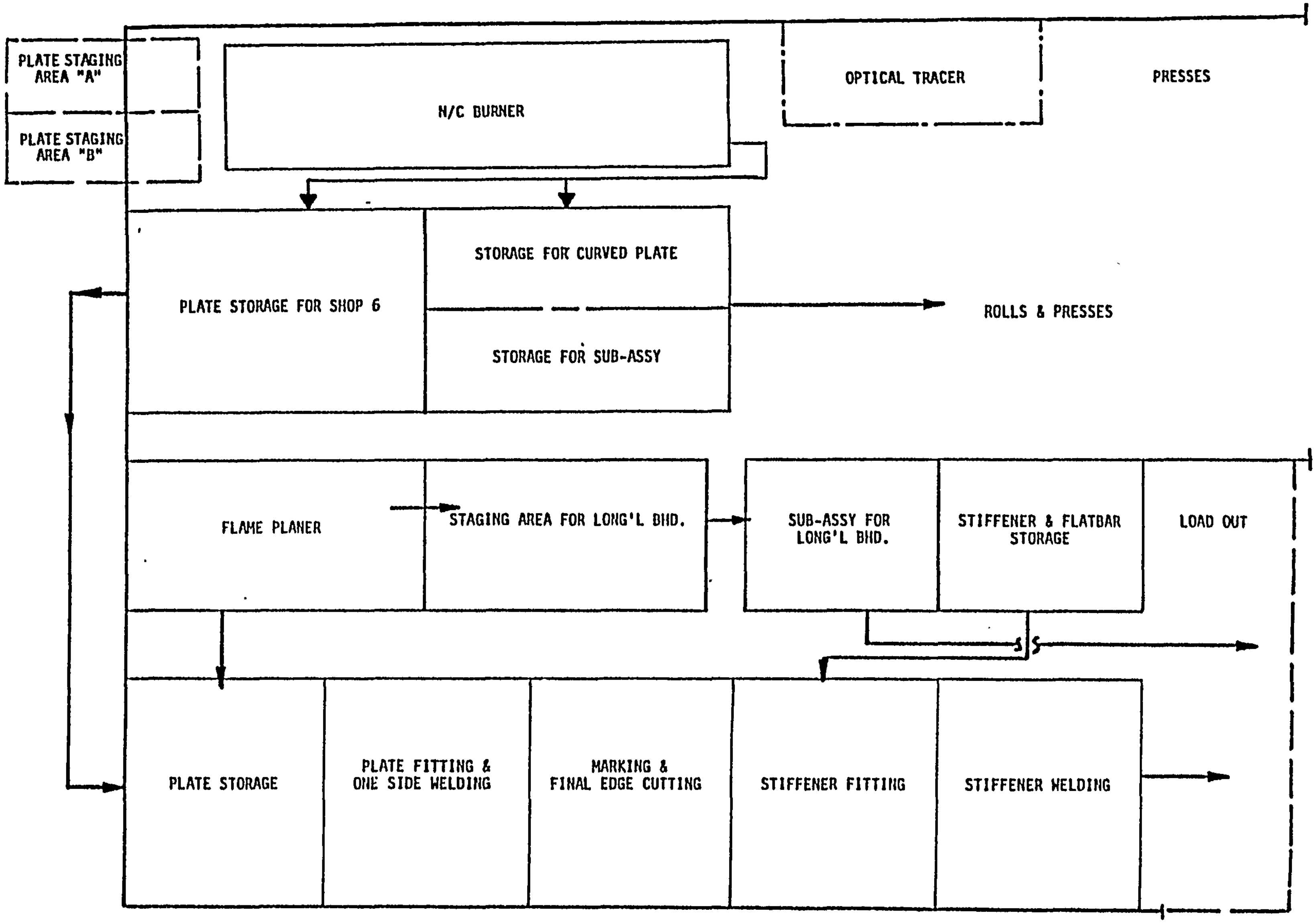
ITEM		COMPANY / FUNCTION	LEVINGSTON	IHI					
		FUNCTION	All ROUND	ALL ROUND	SIMPLE	MARKING	ALL ROUND	ALL ROUND	MULTI.TORCH
INSTALLATION DATE			April, '75	Oct., '71	Sept., '72	April, '75	1974	Aug., '71	Sept., '74
MAKER		Burning Machine	CRD N/C 3000	Koike, Japan	Tanaka, Japan	Tanaka, Japan	Tanaka, Japan	Tanaka, Japan	Koike, Japan
MAKER		Controller	Kongsberg CNC 500	Toshiba T-1500C	Toshiba T-1300G	IHI MK-240M	Toshiba T-1500	Toshiba T-1500	Toshiba T-40
CAPACITY	BURNING MACHINE	Effective Rail Span	29'-7"	31'-2"	18'-2"	16'-3"	39'-0"	58'-6"	16'-9"
CAPACITY	BURNING MACHINE	Effective Rail Length	111'-0"	56'-3"	74'-8"	74'-8"	97'-6"	73'-2"	58'-6"
CAPACITY	BURNING MACHINE	Weight		10 MT	2 MT	0.7 MT	8 MT	13 MT	1.5 MT *3
CAPACITY	BURNING MACHINE	Gas Pressure Used	O_2: 120 PSI Natural Gas: 15 PSI	O_2: 9kg/cm^2 LPG: 65kg/cm^2	→		→	→	→
CAPACITY	BURNING MACHINE – SPEED	Cutting	2-50 IPM/15-250IPM	0.4-60 IPM	2-51 IPM		0.4-118 IPM	→	→
CAPACITY	BURNING MACHINE – SPEED	Marking	20.83'/Min.	39'/Min.	19.5'/Min.	58.5'/Min.	39'/Min.	→	→
CAPACITY	BURNING MACHINE – SPEED	Rapid Transverse	20.83'/Min.	39'/Min.	19.5'/Min.	58.5'/Min.	39'/Min.	→	→
CAPACITY	BURNING MACHINE	Marking Precision		± 1/64"	→	± 1.5/64"	± 1/64"	→	→
CAPACITY	BURNING MACHINE	Gas Used	Natural Gas	LPG	→	→	→	→	→
CAPACITY	BURNING MACHINE – TORCH BLOCK	Torch Station	6(2 Master, 4 Slave)	4	3	1	2	3	3
CAPACITY	BURNING MACHINE – TORCH BLOCK	Bevel	I.K.V.X.Y	I.K.V.X.Y	I		I	I.V.Y	I
CAPACITY	BURNING MACHINE – TORCH BLOCK	Nozzle Tip	Oxweld Made	IHI Made	Koike 106PD	Tanaka	Tanaka 3155A	Tanaka-Curtain	Tanaka-Curtain
CAPACITY	BURNING MACHINE – TORCH BLOCK	Height Sensing	Fluidic	Fluidic	Fluidic		Fluidic	Roller	Roller
CAPACITY	BURNING MACHINE – TORCH BLOCK	Rotating Torch	Equipped	Equipped				Equipped	Equipped
CAPACITY	BURNING MACHINE – TORCH BLOCK	Ignition Extinguish	Automatic	Automatic	Manual	Automatic	Automatic	Automatic	Manual
CAPACITY	BURNING MACHINE – TORCH BLOCK	Piercing	Automatic	Automatic	→		→	→	→
CAPACITY	BURNING MACHINE – TORCH BLOCK	Marking	Center-punched	Plastic Burned	Zinc Burned	→	→	→	Plastic Burned
CAPACITY	BURNING MACHINE	Driving Motor	D.C. Servo	D.C. Servo	→	→	→	→	→
CAPACITY	CONTROLLER	Control Axis	X.Y.θ	X,Y1-2,θ1-2	X.Y	X.Y	X.Y	X.Y.θ	X.Y.θ
CAPACITY	CONTROLLER	Minimum Dimension Input	1/64"	0.1/64"	→	→	→	→	→
CAPACITY	CONTROLLER	Maximum Dimension Input	120'	1230'	→	→	→	123'	1230'
CAPACITY	CONTROLLER	Tape Format	ESSI	EIA-8U	→	→	→	→	→
CAPACITY	CONTROLLER	Interpolation	Linear and Circular	Linear & Cir.	→	→	→	→	→
CAPACITY	CONTROLLER	Kerf Compensation	Dial Set	Dial Set			Dial Set	→	→
CAPACITY	CONTROLLER	Reversing	Direct on Path Program Rev.	Dir. on Path Prog. Rev.	→	→	→	→	→
CAPACITY	CONTROLLER	Auxi. Function		36	28	32	33	51	27
CAPACITY	CONTROLLER	Others							
CAPACITY	CONTROLLER								
PAST RECORD									
PAST RECORD	CUTTING SPEED	3/8" T 5/8"	Variable	51 IPM	24 IPM		30 IPM	28 IPM	24 IPM
PAST RECORD	CUTTING SPEED	5/8" T 3/4"		47 IPM	20 IPM		26 IPM	26 IPM	22 IPM
PAST RECORD	CUTTING SPEED	3/4" T 7/8"		31 IPM	16 IPM		22 IPM	24 IPM	20 IPM
PAST RECORD	CUTTING SPEED	7/8" T		31 IPM	15 IPM		20 IPM	20 IPM	18 IPM
PAST RECORD		Consideration for Torsion	Water Cooling Cutting Seq., Bridging	Cutting Seq. Wtr. Cooling	→		→	→	Cutting Seq. Bridging
PAST RECORD		Troubles Up-to-date							
ADMINISTRATION	MAINTENANCE	Daily	Electronic Tech.	Operator	→	→	→	→	→
ADMINISTRATION	MAINTENANCE	Periodical	Electronic Tech.	2 Times/Yr. Maker	→	→	→	→	→
ADMINISTRATION	MAINTENANCE	Repairing	Maker & Elect.Tech.	Maker IHI Specialist	→	→	→	→	→
ADMINISTRATION	OPERATOR	Number	3	2	2	2	4	4	1
ADMINISTRATION	OPERATOR	Experience	4-5 years	2-3 Years	3.5 Yrs.	1.5 Yrs.	1.5 Yrs.	3 Yrs.	1.5 Yrs.
Max. Plate No. to be Cut Simultaneously			4 PL(12'-0"50'-0")	2 PL(12'*34')	1 PL(15'*75')	1PL(15'*75')	2PL(115'*98')	3PL(16'*46')	1PL(12'*9')
REMARKS			DNC	Tokyo - 1 Chita - 1 AIOI - 1	Chita - 1	Chita - 1 Yokohama-2	Chita - 2 AIOI - 2	Kure - 2	Kure - 2

TABLE T1-3

TABLE OF EFFECTIVE CUTTING MACHINES

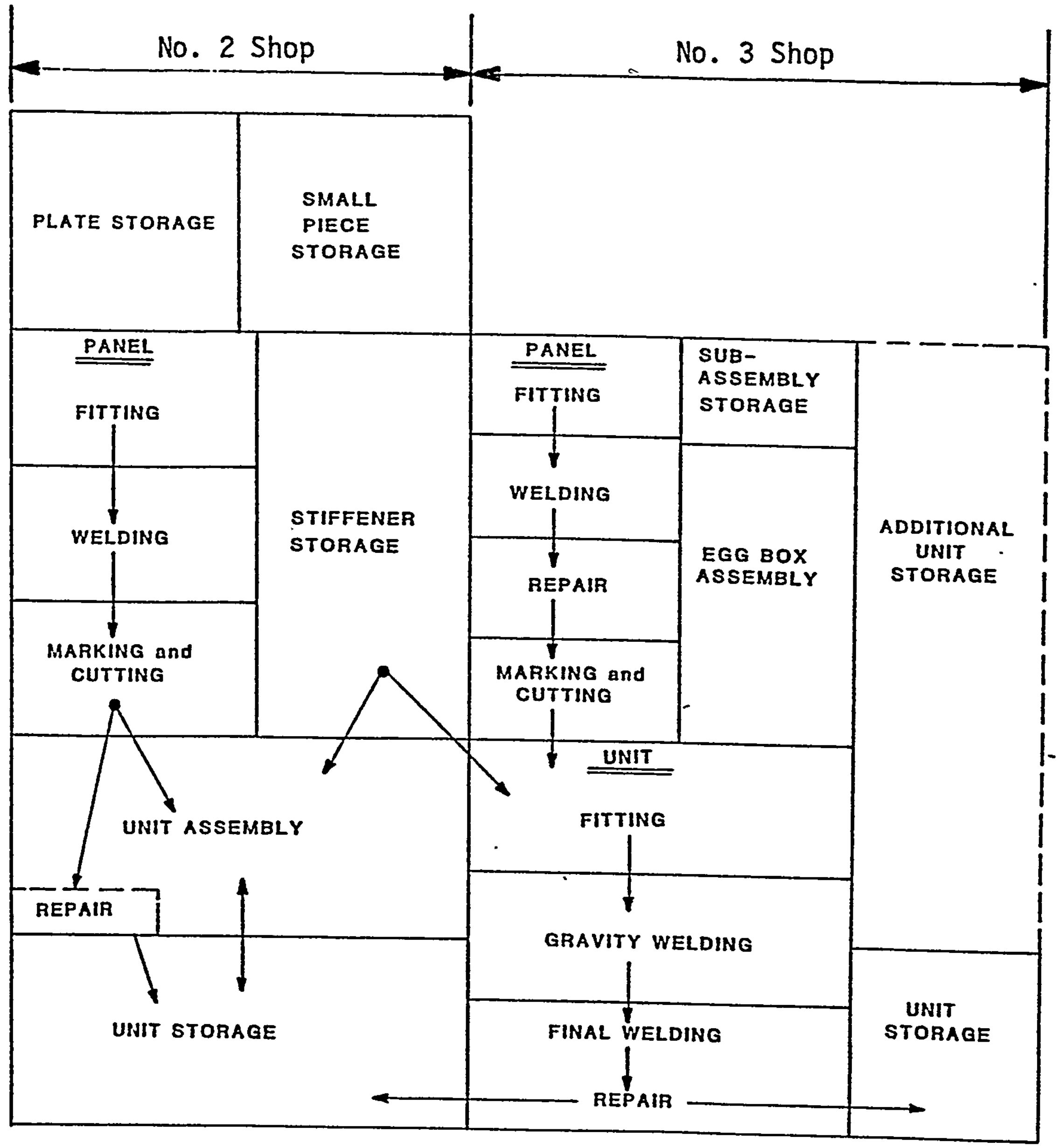
CUTTING STAGE	CATEGORY OF PIECES	EFFECTIVE CUTTING MACHINE	METHOD	RECOMMENDED SELECTION FOR LSCo	
Long'l & FB	Long'l	Automatic Long'l cutting machine & semi-automatic machine	Butt: Automatic Long'l Cutter Slot Hole: Semi-automatic machine	X	1. Auto machine is not completely implemented. 2. Auto machine is not cost-effective due to low volume.
		Manual & semi-automatic machine	Butt: Manual Slot Hole: Semi-auto machine	O	
	Flat Bar	Automatic Long'l cutting machine & semi-automatic	Butt: Automatic long'l cutter Slot Hole: Semi-auto machine	X	
		Manual & semi-automatic machine	Butt: Manual Slot Hole: Semi-auto machine	O	
Curved Plates	Curved Plates	NC Gas Cutter	NC Marking → NC Gas Cutter	O	1. Because of few manhours.
		Semi-automatic machine	Manual Marking → Semi-auto machine	X	
Internals	Floor & long'l Bhd with few edge preparation or no edge preparation	NC Plasma Cutter	NC Marking → NC Plasma Cutter	O	1. Because of more precise accuracy. 2. Because of few manhours.
		NC Gas Cutter	NC Marking → NC Gas Cutter	O	
		Semi-automatic machine	EPM-Marking → Semi-auto machine Photo-Marking → Semi auto machine Manual-Marking → Semi-auto machine	X	
	Floor & long'l Bhd with edge preparation	NC Gas Cutter	NC Marking → NC Gas Cutter	O	In Japan O and X are reverse. But in U.S., NC gas cutter is better due to awkward manual cutting & less investment.
		Semi-automatic machine	EPM-Marking → Semi-auto machine Photo-Marking → Semi-auto machine Manual-Marking → Semi-auto machine	X	
	Small Pieces	NC Plasma Cutter	NC Marking → NC Plasma Cutter	O	More Speedy and less shrinkage than NC Gas Cutter.
		NC Gas Cutter	NC Marking → NC Gas Cutter	A	
		Semi-automatic machine	EPM-Marking → Semi-auto machine Photo-Marking → Semi-auto machine Manual-Marking → Semi-auto machine	X	In U.S., manual cutting is awkward.
	Small pieces which are usually cut out from scrap	Optical Tracer		O	
		NC Plasma Cutter	Small pieces are put in between big pieces. After big pieces are cut, they are manually or automatically cut.	O	
		NC Gas Cutter		O	
		Semi-auto machine	Manual-Marking → Semi-auto machine	X	
Panel	Panel Plate	Flame Planer	Manual-Marking → Plane cutter EPM-Marking → Plane cutter Photo-Marking → Plane cutter	O	Manual marking = low manhours.
		Semi-automatic machine	Manual-Marking → Semi-auto machine	X	

O: Suitable
A: Fair
X: Unsuitable



IHI PROPOSED LAYOUT - SHOPS 5 & 6

FIGURE 1-14



IHI PANEL LINES

FIGURE 1-15

However, their assistance in this area influenced the proposed lay out and material flow within Shop 5 (Fabrication) and Shop 6 (Panel Line), and utilization of the machines within these shops.

The lay out and material flow proposed to Livingston by IHI was shown on Figure 1-14. The arrangement decided upon by Livingston, shown in Figure 1-16, is similar to IHI’s proposal.

Sand Blasting/Shot Blasting

The general flow of painting work at IHI is described in the flow chart of Figure 1-17. Sketches of each enclosed painting facilities are provided on Figures 1-18 through 1-21.

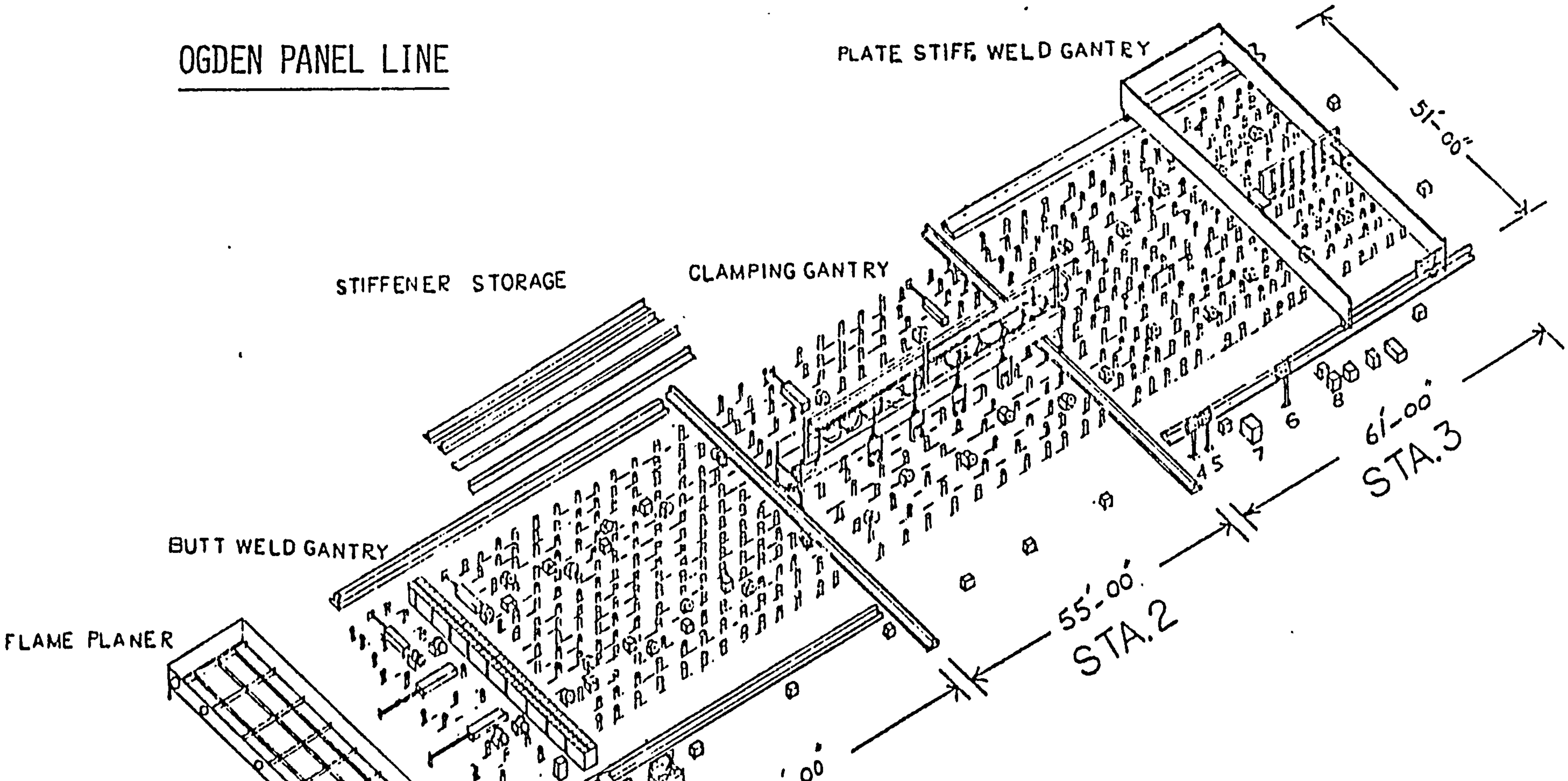
IHI introduced to Livingston the concept of painting units at the assembly stage prior to erection, which has resulted in considerable savings, estimated to be about 40 per cent per unit. Savings resulted from less time moving labor and materials to the work place, fewer cramped work spaces, better supervision, less scaffolding requirements, and fewer premium hours caused in attempts to avoid disturbing other trades.

OUTFITTING

The basic production process is illustrated schematically in Figure 1-22. This chart depicts inputs and outputs in terms of tonnage and labor man hours used. The evidence of a high amount of “pre-outfitting" can be determined from the data given. The pre-outfitting composes 73 per cent by weight, and 27 per cent by labor man hours, of the total for outfitting.

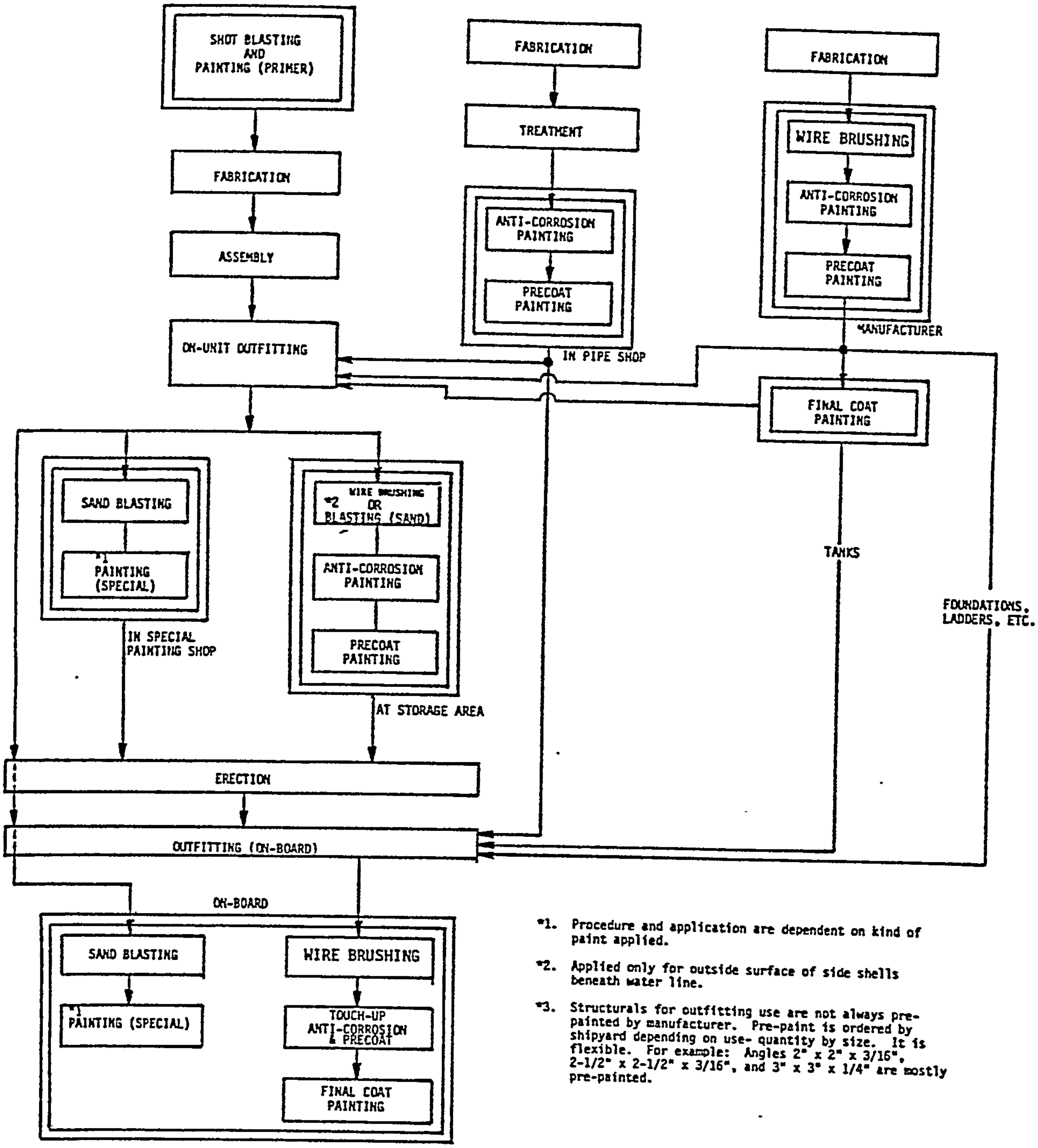
The total outfitting process is shown in Figure 1-23. This chart illustrates the importance of composite drawings and of palletizing

OGDEN PANEL LINE



NO.	EQUIPMENT
1	STA. 1 CONVEYOR CONTROL PANEL
2	MAGNET CONTROL PANEL
3	HYDRAULIC UNIT
4	STA. 2 PLATE POSITIONER
5	STA. 2 CONVEYOR CONTROL PANEL
6	STA. 3 PLATE DRIVE CONTROL PANEL
7	460 V.3Ø
8	6 - 600 AMP. W/M
9	2 - 1200 AMP. W/M

FIGURE 1-16



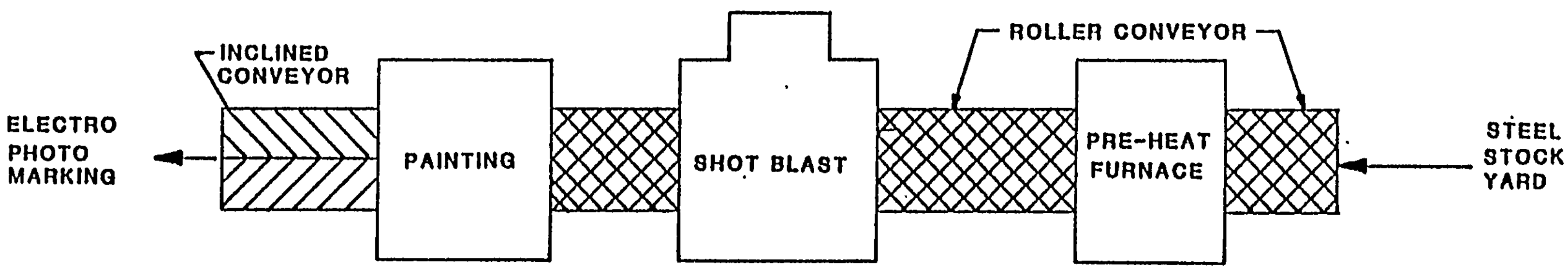
*1. Procedure and application are dependent on kind of paint applied.

*2. Applied only for outside surface of side shells beneath water line.

*3. Structurals for outfitting use are not always pre-painted by manufacturer. Pre-paint is ordered by shipyard depending on use- quantity by size. It is flexible. For example: Angles 2" x 2" x 3/16", 2-1/2" x 2-1/2" x 3/16", and 3" x 3" x 1/4" are mostly pre-painted.

GENERAL WORK FLOW

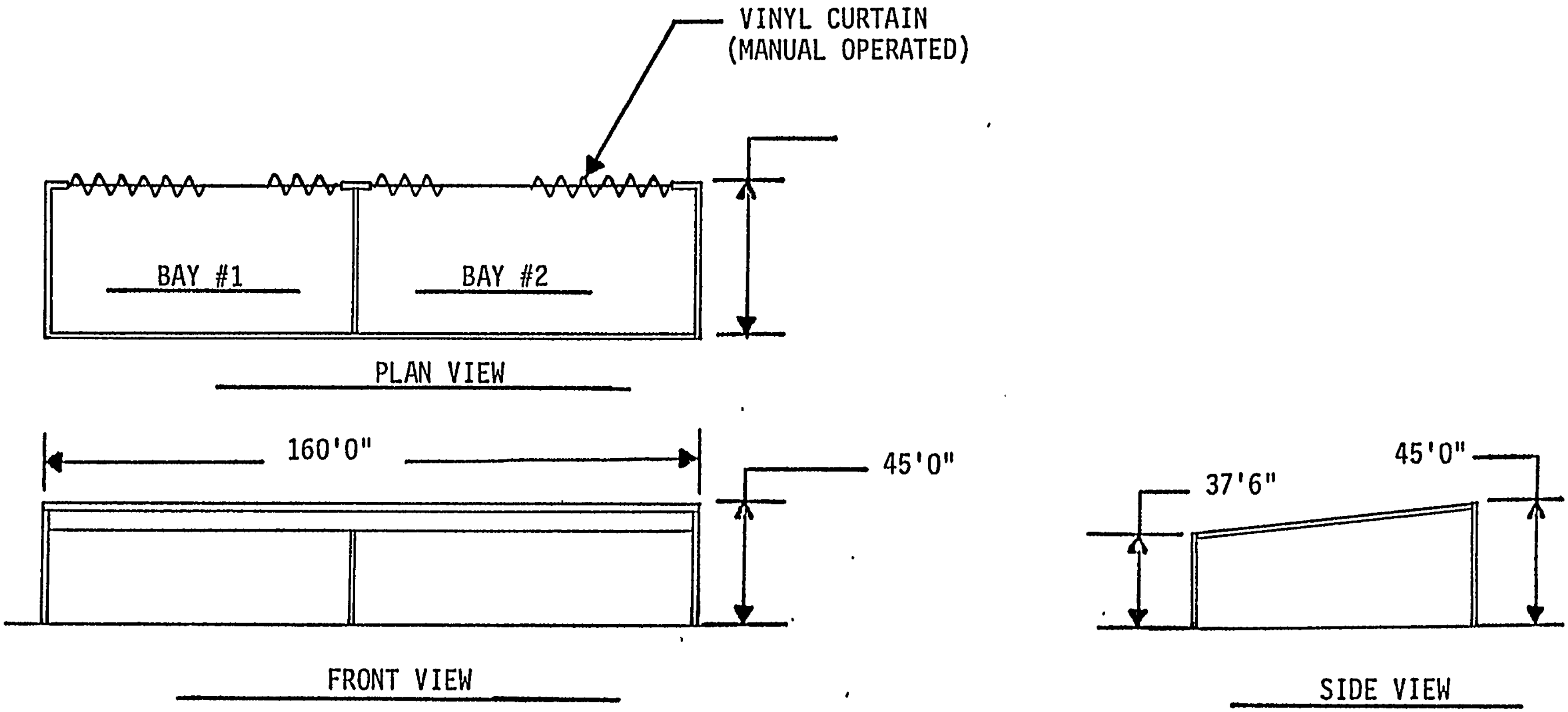
FIGURE 1-17



FABRICATION SHOP

SHOT BLAST FACILITY

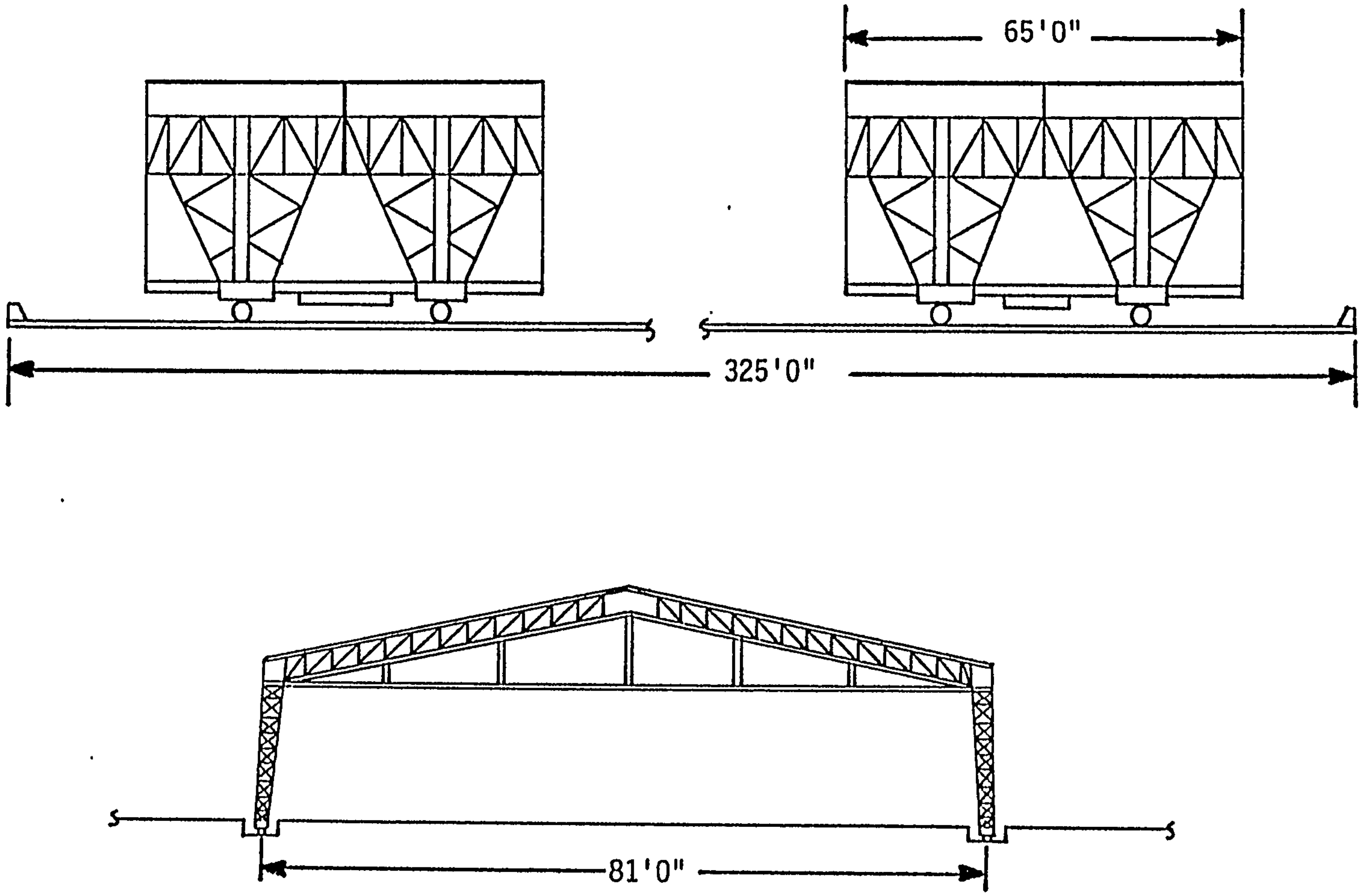
FIGURE 1-18



NO. 1 BLOCK PAINTING BUILDING

FIGURE 1-19

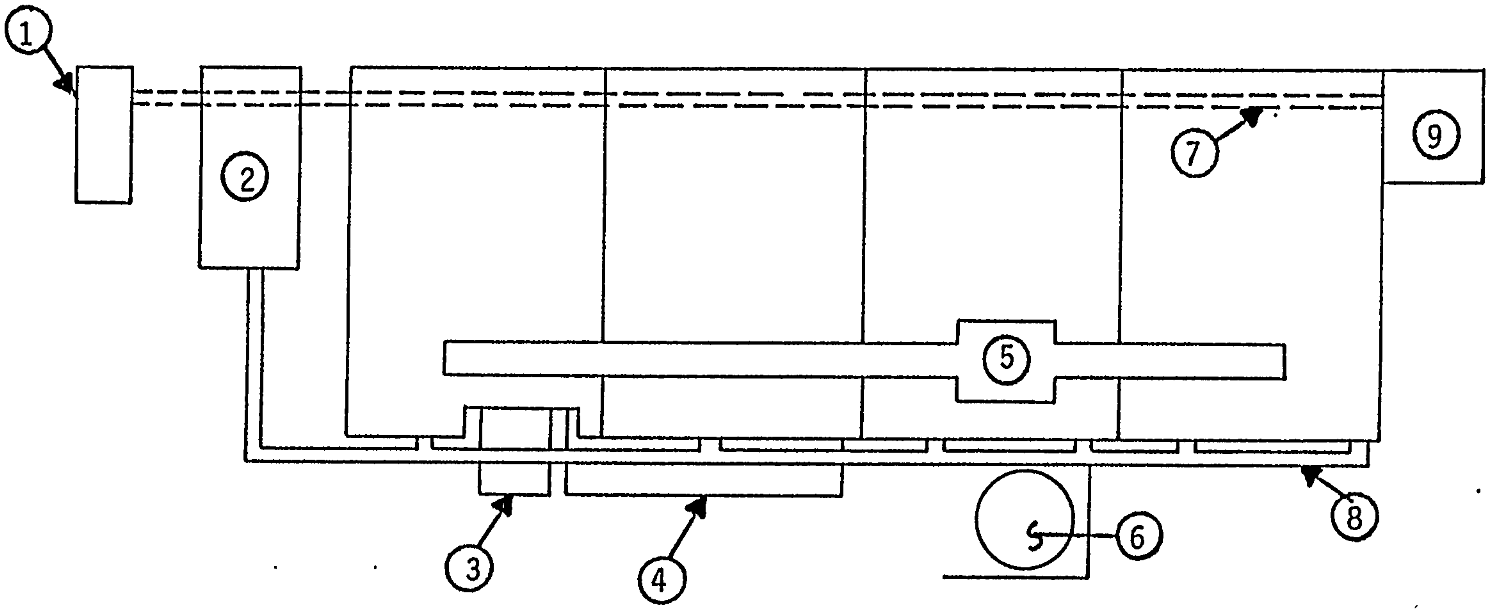
NOTE: ONLY 2 OF 3 SECTIONS SHOWN



NO. 2 BLOCK PAINTING BUILDING

FIGURE 1-20

1. HEATED AIR UNIT
2. DUST COLLECTOR
3. CLEAN SAND HOPPER
4. CLEAN SAND CONVEYOR
5. SAND COLLECTION PIT
6. USED SAND HOPPER
7. HEATED AIR DUCT
8. EXHAUST DUCT
9. HEATED AIR UNIT



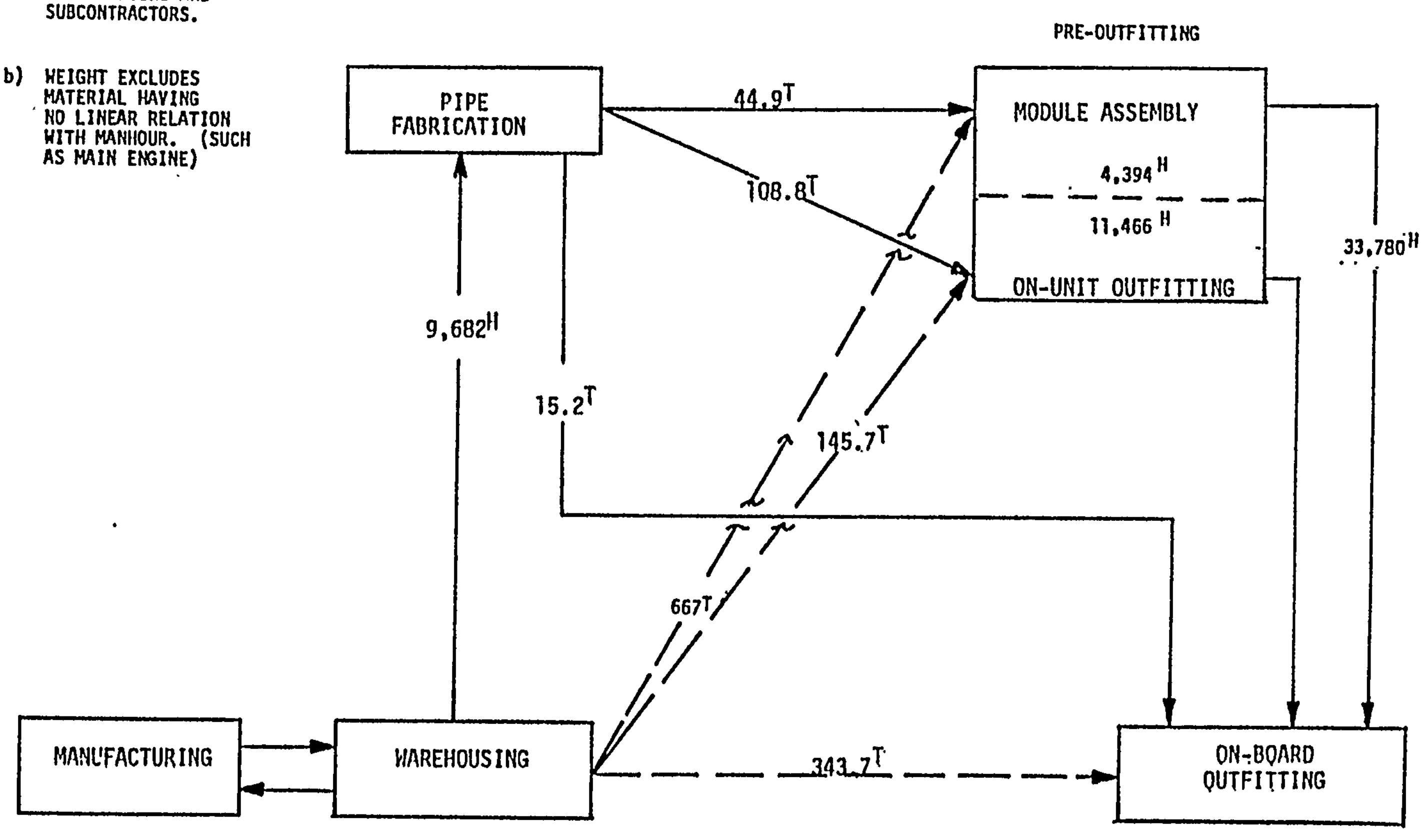
SPECIAL PAINT SHOP

FIGURE 1-21

NOTE

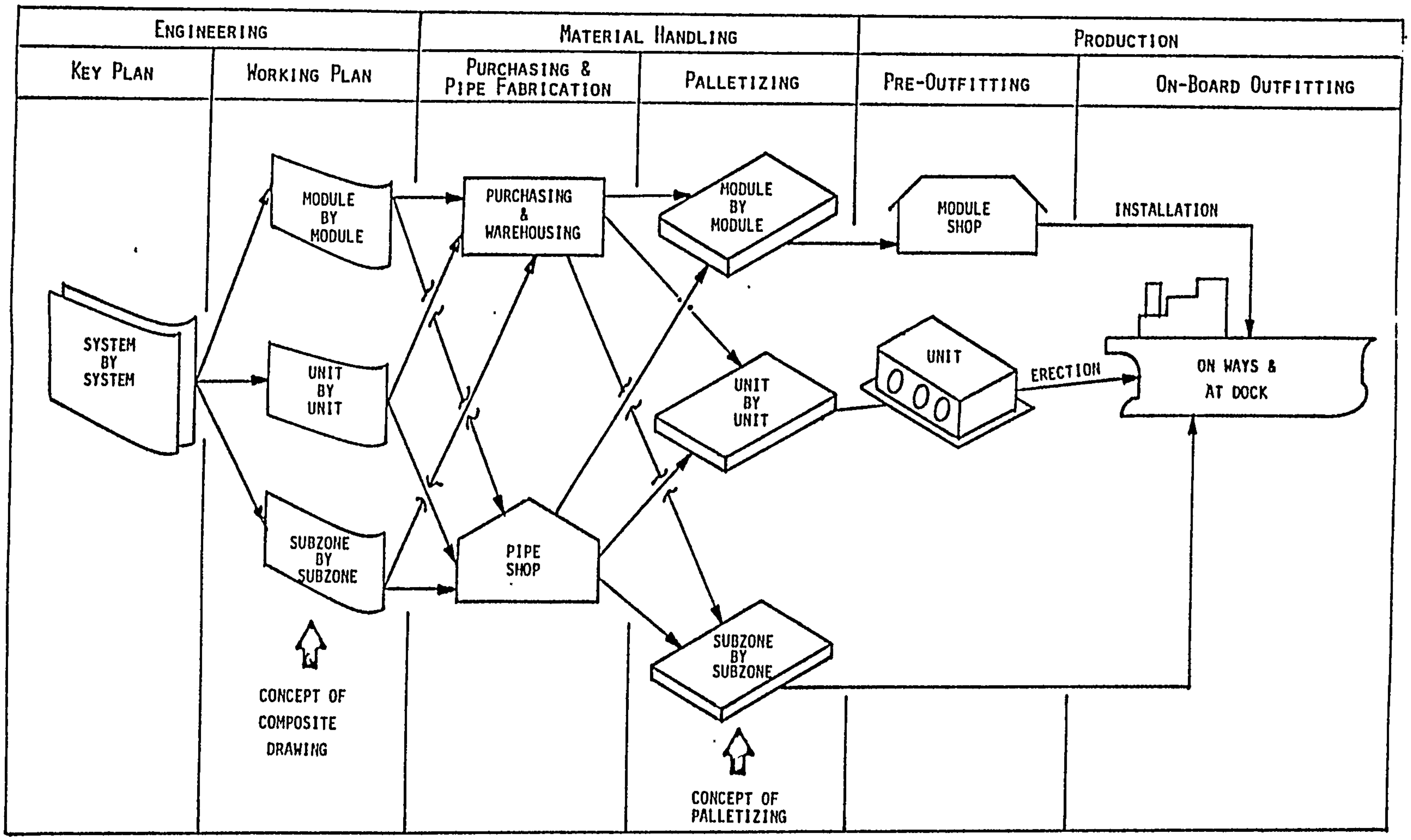
a) EXCLUDING MANHOURS FOR PAINTING AND SUBCONTRACTORS.

b) WEIGHT EXCLUDES MATERIAL HAVING NO LINEAR RELATION WITH MANHOUR. (SUCH AS MAIN ENGINE)



BASIC OUTFITTING PROCESS

FIGURE 1-22



TOTAL OUTFITTING PROCESS

FIGURE 1-23

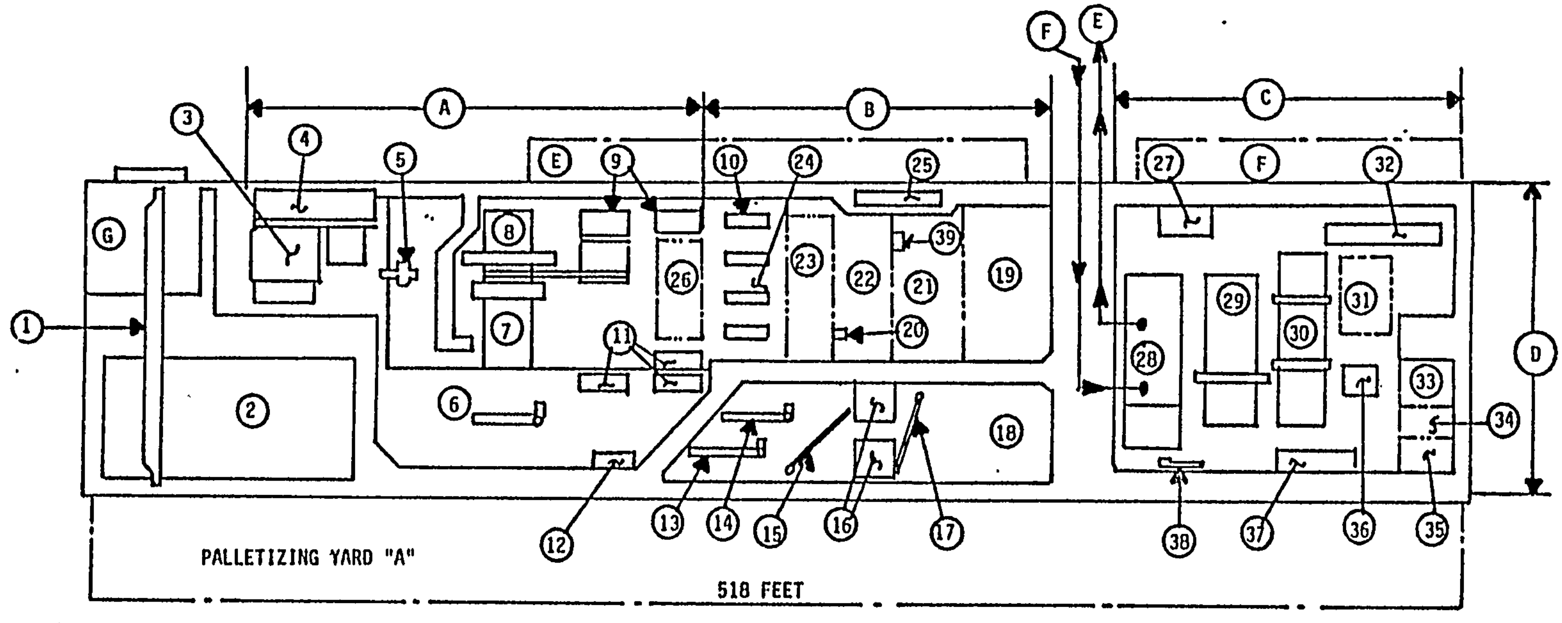
to the concept of effective pre-outfitting. The-basic objective of this concept is to minimize on-board work, thereby shifting the work to more productive and safer conditions in shops and on land.

Pipe Fabrication

IHI practices mass production, assembly line and automated methods in its pipe fabricating process. The layout and flow of work in the pipe shop is indicated in Figure 1-24. This sketch shows that pipe fabrication work is performed in separate sections of the shop according to pipe size, with 3" pipe size being the dividing line. A full process line is available at each separate location in this shop for the size pipe being fabricated, with the exception of pipe bending of large pipe, which is performed in a separate building. A schematic diagram of the pipe fabrication process in the small pipe lane section at IHI-Aioi is provided as Figure 1-25. Automation is employed at virtually every step in the pipe fabrication process, including transporting of pipe from station to station by conveyor. The type of bending to be applied on steel pipe is shown on Table T1-4.

The major recommendation made by IHI to Livingston concerning pipe fabrication was the fundamental change in concept between shop fabrication and on-board installation of pipe. Prior to TTP, Livingston performed virtually all pipe work on-board a vessel at the erection site. Much of the pipe fabrication was also performed on-board, by moving portable cutters, threaders, manual pipe benders, and bevel machines to the erection site. The pipe shop served as a place to perform some repetitive work and for pipe fabricating jobs done in inclement weather.

Consequently, IHI recommendations were directed at changing the whole system so that the pipe shop could serve as a true fabrication shop, including pipe assembly work.



A AUTOMATIC FABRICATION LINE - 2-1/2" & BELOW
B MANUAL FABRICATION LINE - 2-1/2" & BELOW
C MANUAL FABRICATION LINE - 3" & ABOVE
D 115 FEET
E PALLETIZING YARD "B"
F PALLETIZING YARD "C"
G OFFICE

1. OVERHEAD CRANE
2. STAGING AREA AFTER TREATMENT
3. AUTOMATIC PIPE RACKER
4. DIGITAL CUTTING
5. 2-POINT WELDER
6. N/C BENDER - TYPE 4
7. 4-POINT WELDER
8. 4-POINT ASSEMBLER
9. STORAGE RACKS
10. FITTING SLAB
11. STORAGE RACKS
12. STORAGE RACK
13. BENDER TYPE 2
14. BENDER TYPE 4
15. JIB CRANE
16. FITTING SLABS
17. JIB CRANE
18. FABRICATION AREA FOR PIPING MODEL
19. STAGING AREA
20. ROLLER & WELDER
21. FINISHING AREA
22. WELDING AREA
23. BUFFER ZONE
24. FABRICATION SLABS
25. ELECTRIC SUB-STATION
26. BUFFER ZONE
27. FABRICATION SLAB
28. PIPE RACK
29. MARKING RACK
30. WELDING AND STORAGE RACKS
31. MARKING & FINISHING AREA
32. FABRICATION SLAB
33. FINISHING AREA
34. BUFFER ZONE
35. WELDING AREA
36. FABRICATION SLAB
37. FABRICATION SLAB
38. PIPE COASTER
39. DRILLING MACHINE

IHI (AIOI) PIPE SHOP LAYOUT

FIGURE 1-24

PIPE FABRICATION PROCESS (1/2"-2 1/2")

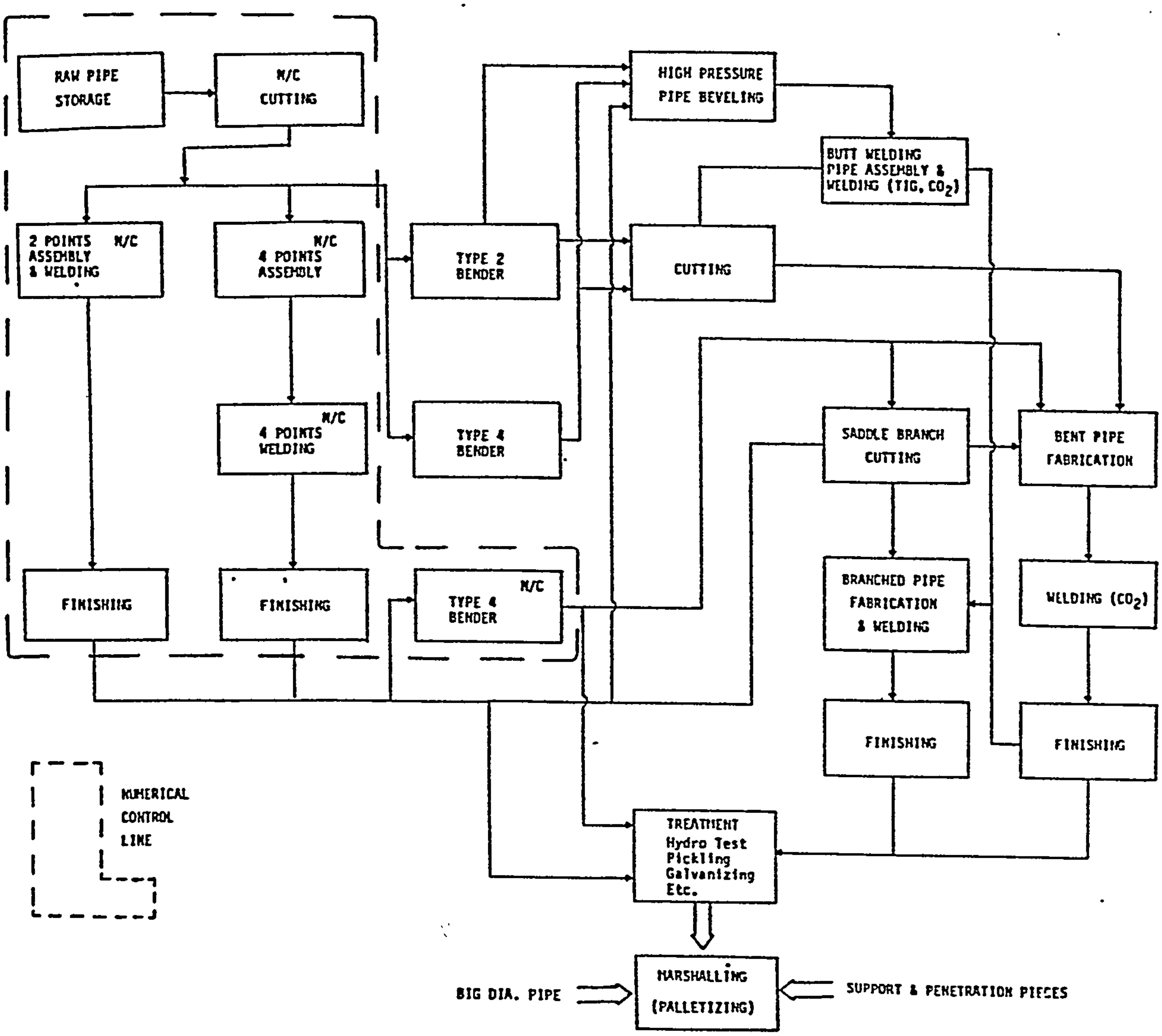


FIGURE 1-25

TABLE T1-4

PRODUCTIVITY COMPARISON

PREOUTFITTING VS. ONBOARD OUTFITTING

Categories		Parametric * Weight (T)	Manhour (H)	Efficiency (H/T)
On-Module	Main floor modules	46.1	980	21.3
	Modules with cooler flat	6.2	190	30.6
	Other modules	40.0	484	12.1
	Welding	-	230	-
	Crane operation	-	170	-
	Sub-total	92.3	2054	21.6
On-Unit	Inner bottom units	4.3	215	50.0
	L.E.F. & U.E.F. Units	12.1	698	57.7
	Main Deck Units	16.7	782	46.8
	in Casing	16.9	979	57.9
	Side Shell Units & Other Units	17.5	525	30.0
	Welding	-	710	-
	Sub-total	67.5	3909	57.9
Preoutfitting Total		159.8	5963	37.3
On-Board	Piping	18.7	3078	164.6
	Steel Fitting	21.5	2240	104.2
	Others	6.9	1430	207.2
	Welding	-	980	-
	Sub-total	47.1	7728	164.1
Grand Total		206.9	13691	66.2

* Short ton: Weight of material such as pipes, valves, foundations, ventilation ducts, and so on, which are considered to have linear relation to manhour spent to install them.

The above table manifests the superiority of preoutfitting over onboard outfitting, i.e. on-module outfitting has 1/7 of on-board outfitting H/T, on-unit outfitting has 1/3, and totally preoutfitting has 1/4. Further 159.8 tons (77%) of total outfitting weight in engine room, 206.9 tons, is preoutfitted.

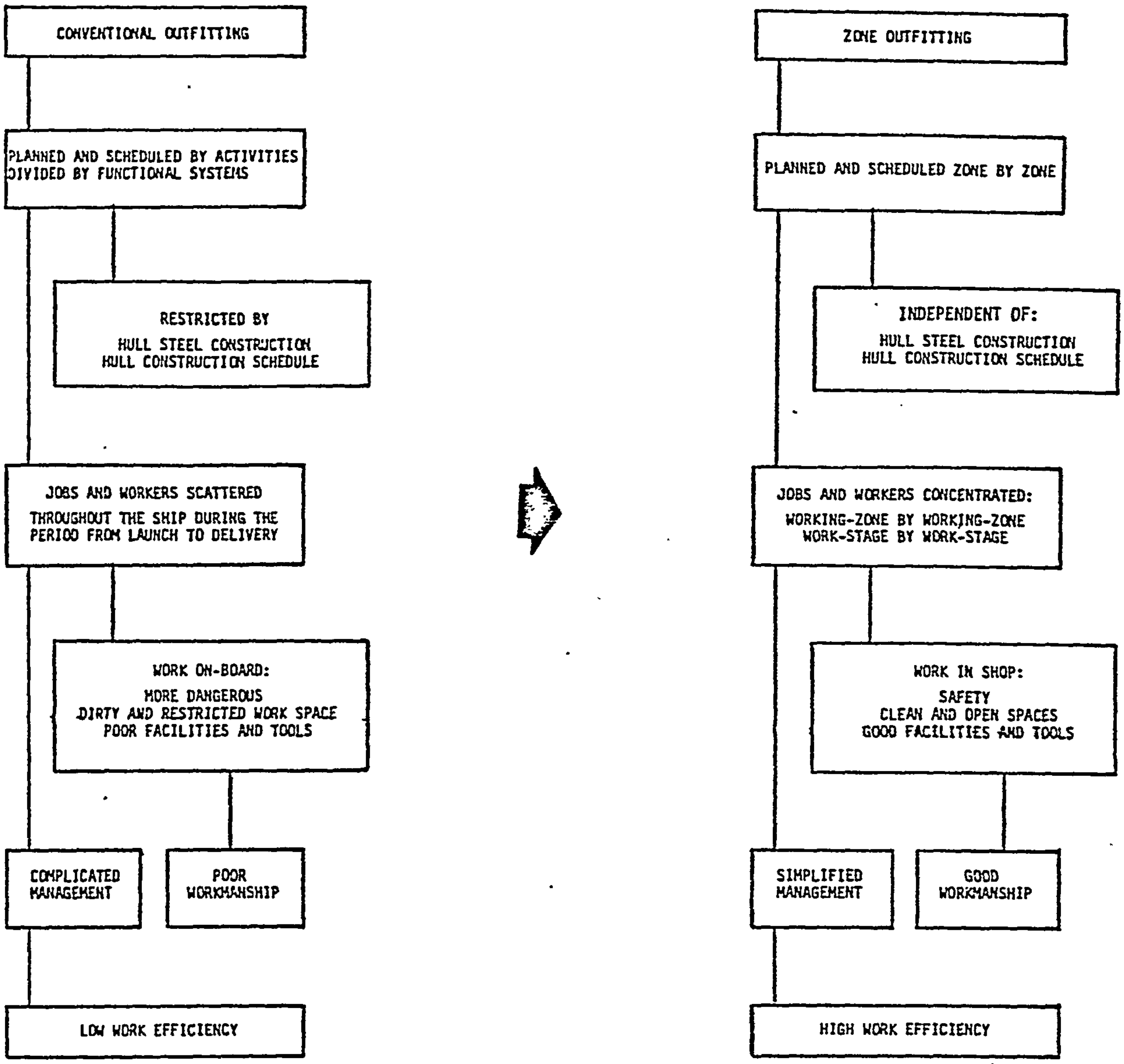
IHI recommended a new pipe shop for Livingston, with a layout utilizing the fabrication lanes concept. Further recommendations included increased automation and greater utilization of the computer in cutting and bending plans.

Livingston is still in the process of implementing systems and procedures to take advantage of the methods that can be adopted at low investment costs. The methods involving greater capital expenditure will be reviewed as the facilities, such as the proposed pipe shop, are implemented.

Zone Outfitting

IHI adopted the concept of zone outfitting in order to shorten construction periods. The advantages of zone outfitting over conventional outfitting are identified in Figure 1-26. In particular, benefits were achieved significantly between keel laying and launch dates. Zone outfitting is an attempt to shorten the total construction period through an overlapping of steel and outfitting without interference between them. This concept is illustrated in Figure 1-27. The overlap of steel and outfitting resulted in over 50 per cent completion of total outfitting by launch date.

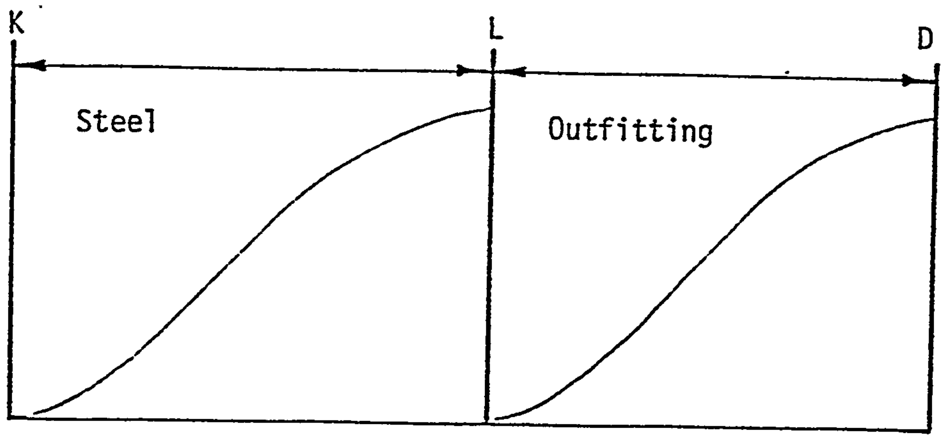
The zone outfitting approach released outfitting work from dependence on steel construction progress and from the ship's system arrangement. The zone approach permits and encourages most of the outfitting to be accomplished earlier and in shops or places other than erection sites. It is product-oriented in that it ignores systems during the construction phase and instead focuses on production of interim products. The benefits of this approach, in addition to a shorter construction period, include



ZONE OUTFITTING

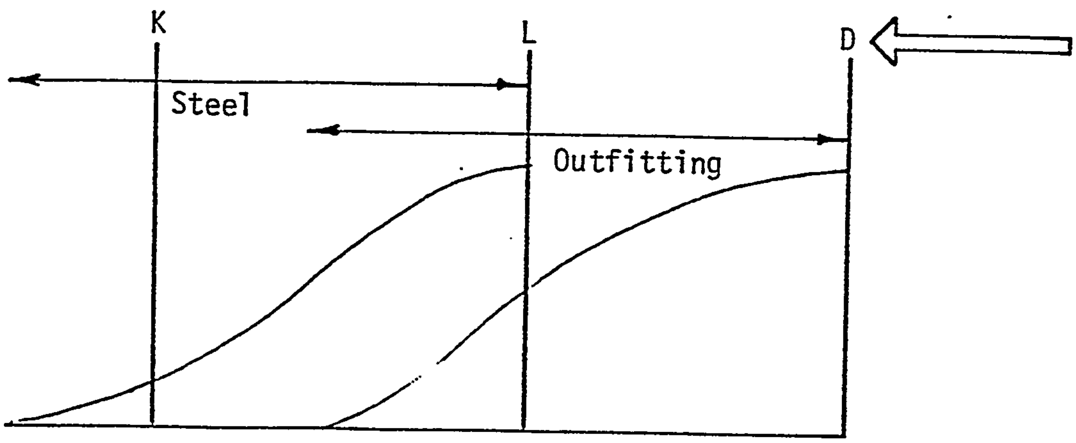
FIGURE 1-26

WITHOUT PRE-OUTFITTING



K = Keel Laying
L = Launching
D = Delivery

WITH PRE-OUTFITTING



Overlapping of steel and outfitting
enabled more than 50% completion
of total outfitting as of launching.

OVERLAP OF STEEL AND OUTFITTING

FIGURE 1-27

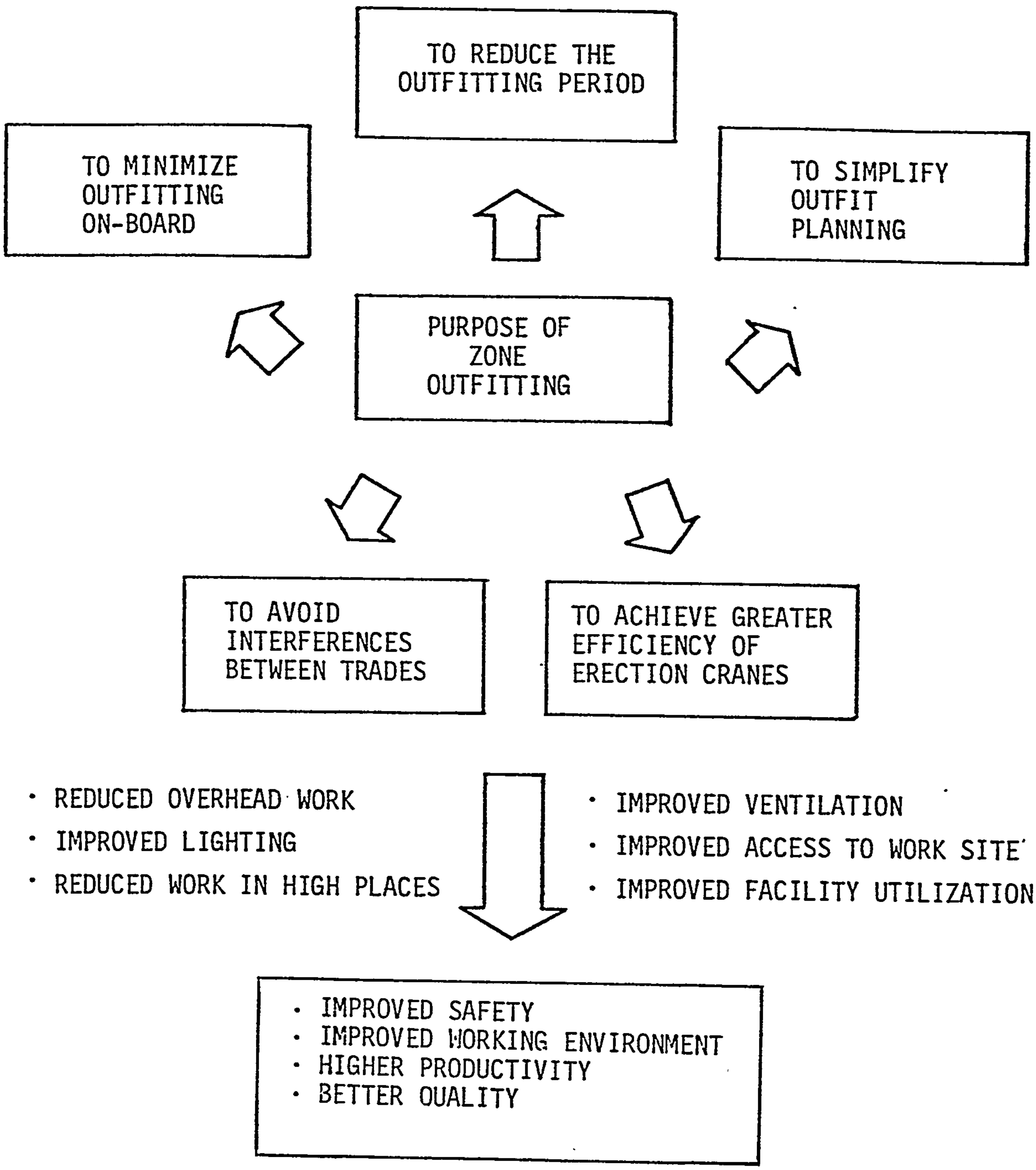
safer work, reduced cost, better quality and adherance to schedules. Figure 1-28 summarizes the goals and benefits of zone outfitting.

Zone outfitting features three basic stages: on-module, on-unit, and on-board. On-module and on-unit outfitting are generally referred to as "pre-outfitting".

Pre-outfitting generally can be classified into either on-module or on-unit outfitting. On-module outfitting is the assembly of an interim product consisting-of manufactured and purchased components. On-module outfitting is given the highest priority at IHI despite the impact it may have on steel construction progress or even hull design. For example, in construction of the engine room innerbottom tank top, the side shell and bulkhead are elevated six to ten feet to avoid interference between modules and the side shell web during side shell erection.

On-unit outfitting is the installation of outfit components onto a hull unit during its assembly and/or after its completion. It is the next best alternative to on-module outfitting. On-unit outfitting may be done on a hull assembly slab, or a unit may be moved to an area (inside or outside) that is designated for outfitting.

Although on-unit outfitting requires close coordination between steel, outfitting and painting, it provides much better working conditions, accessibility and utilization of equipment than on-board work. On-unit outfitting on the engine flat units is especially beneficial due to the heavy concentration of material beneath the flats and the ability to apply downward installations on units that can be placed in an inverted position. IHI practices extensive application of on-unit outfitting on engine flat units.



GOALS AND BENEFITS OF ZONE OUTFITTING

FIGURE 1-28

As a result of high pre-outfitting, the on-board outfitting can be limited to the connection of modules and pre-outfitted units, final painting, tests and trials. Realistically, however, some installation of outfit components in a hull will remain for installation at erection sites or outfitting piers which cannot be productively incorporated into on-module or on-unit outfitting.

Incorporation of the pre-outfitting method results in fewer total manhours due to the work being performed under high-efficiency conditions. This is substantiated in Table TI-4 which shows a productivity comparison between pre-outfitting and on-board outfitting. The data was collected from the engine room outfitting of a bulk carrier built at the IHI-Aioi shipyard. In summary, this table portrays on-module outfitting as over seven times more efficient than on-board outfitting; on-unit outfitting three times as efficient; and total pre-outfitting four times faster. In this case, 77 per cent by weight of the outfitting in the engine room was pre-outfitted.

Palletization

The pallet concept is an indispensable system for effective zone outfitting. Literally, a pallet is a container in which materials are contained and transported to the work site for installation. Figure 1-29 shows the design of the type of pallets commonly used at IHI.

The word “pallet” at IHI refers more generally to a unit of work specified by zone, and a unit of materials identified by zone. It is a conceptual approach that allows information from the design, material and production departments to integrate so that each can have a common understanding of shipbuilding management and control.

Pursuing the merits of pre-outfitting inevitably leads to incorporation of palletizing methods. However, the palletizing concept can be

PALLET USED IN IHI

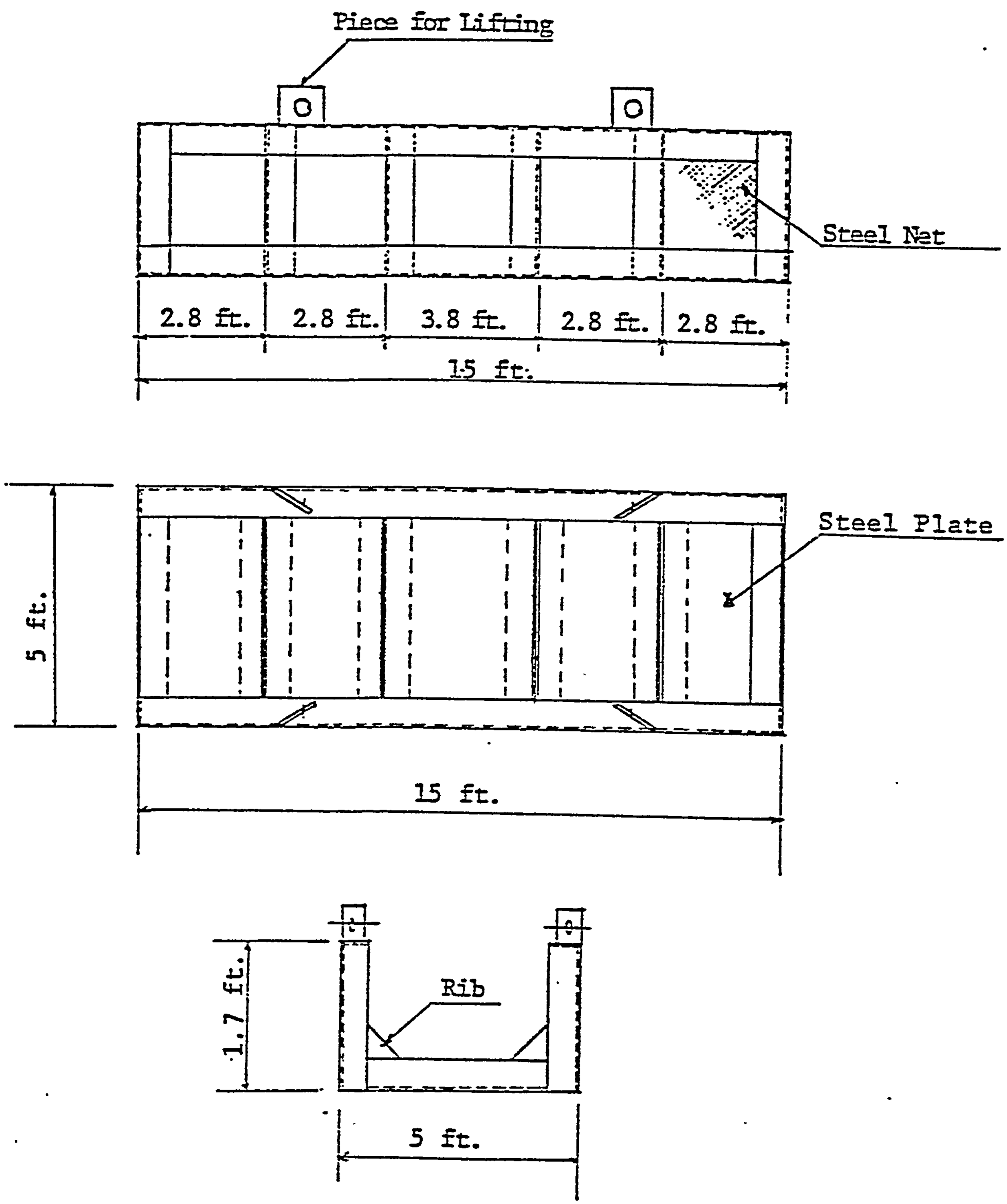


FIGURE 1-29

adopted independently of pre-outfitting development. In pre-outfitting, certain units are specified, such as for a compartment or zone of a ship, a group of fittings surrounding certain machinery, or a group of tubing arrangements. In palletizing, the regional unit can be further divided into regions from the viewpoint of job stages or job procedures. Thus, the palletizing concept may be executed with the primary intention of optimizing the job itself, whether it is at a pre-outfitting or an on-board stage.

It is a fundamental prerequisite that composite drawings and Material Lists for Fitting (MLF's) be prepared for full implementation of the palletizing concept. In order to load materials completely in a pallet, it is convenient to use the MLF as a check-list and to utilize it as a ticket for the materials being issued.

A common use of the pallet system is for the palletizing of pipe and piping components. Other material can also be palletized in conjunction with the composite drawing and the MLF systems, such as electrical supplies, joiner material, ductwork, steel outfittings, etc.

IHI recommended the complete "pallet" concept to Livingston, as a means to improve productivity without a great amount of capital expenditure. Livingston-has made a significant number of changes in its systems and procedures to incorporate this philosophy.

WELDING METHODS

The welding process receives considerable attention at IHI as they regard ship construction as primarily a welding process, all other activities being essentially supporting. This is apparent in the construction methods specified at IHI, where units are turned or built in various positions, even upside-down, in order to accommodate the most efficient welding processes.

lHI avoids overhead welding, cramped positions for welding, manual welding methods and rework. The importance of welding at IHI is also demonstrated in their wide application of welding standards in the determination of assembly times for planning and scheduling purposes.

The welding methods in use at IHI-Aioi are listed in Table TI-5. A midship section showing typical application of automatic welding on a 70,000 DWT bulk carrier is shown on Figure 1-30. Following this sketch is a complementary chart describing automatic welding in modernized shipbuilding, Table T1-6, listing types of welding methods and applications of each type.

The types of welding methods employed at IHI are not significantly different from those used at Livingston. However, significant differences exist between the application of these methods; e.g., the amount of automatic welding, the dictation of construction methods by welding methods, and the adherence to the predetermined welding sequence. The methods employed at IHI and transferred to Livingston include vertical downward welding and gravity welding. Other methods studied jointly by IHI and Livingston include one-sided welding, pipe welding, welding sequence and welding applications at each construction stage.

Vertical downward welding is a process which utilizes a specially designed, Jew-hydrogen type electrode. This welding method is a proven high-efficiency vertical welding method. A comparison between vertical upward and vertical downward welding indicates the downward method is two

Kind of Welding Method	Division	Popular Name	Stage	Part of Mainly Application
CO_2 arc welding	Each side semi-automatic		Al1	Butt & Fillet joint of flat position
	One side semi-automatic		Assembly Erection	Butt & Fillet joint of flat position
	One side automatic	DTM process	Erection	Flat & Vertical butt joint of internal member
Submerged arc welding	Each side one pass		Sub-assembly	Plate joint of panel
	Combined with one side CO_2 arc welding		Assembly Erection	Plate joint of panel
	Combined with manual arc welding		Assembly	Butt joint of curved shell
	One side by apparatus	FCB process	Assembly	Plate joint of panel
	One side with handy backing material	KATAFLUX or FAB	Assembly Erection	Butt joint of curved shell Block joint
	Fillet	MISA	Sub-Assembly	Fillet joint of panel to internal member
Electro-Gas & Electro-Slag welding	Automatic Electro-Gas	Elegas	Erection	Vertical butt join tof S. shell & Bulkhead
	Simplified Electro-Gas	SEG	Erection	Vertical butt joint at short length
	Consumable nozzle Electro-Slag welding	CES	Erection	Vertical butt joint of Longitudinal stiffener member
Horizontal Automatic welding	One side with CO_2 arc welding	M3-ZA	Erection	Horizontal butt joint of Side shell
Non-Gas arc welding	Semi-automatic	Open arc	Erection	Horizontal fillet joint
	Automatic	Open arc	Erection	Horizontal fillet joint between T. Top & Hopper

TABLE T1-5

IHI WELDING METHODS

TYPICAL APPLICATION OF AUTOMATIC WELDING IN BULK CARRIER (70,000 DWT)

1. ASSY. SEAM JOINT
   F.C.B.
3. DECK SEAM, TANK TOP SEAM
   AND BUTT

   F.A.B. OR KATAFLUX
4. ASSY. HORIZONTAL FILLET WELD
   LINE WELDER
7. SIDE SHELL BUTT
   P. ELE - GAS
14. LONG'L BHD BUTT
    ELE - GAS
15. SIDE SHELL SEAM
    M3-Z
16. BOTTOM SHELL BEAM AND BUTT
    OSCON-OB
17. DECK LONG'L BUTT
    C.E.S.

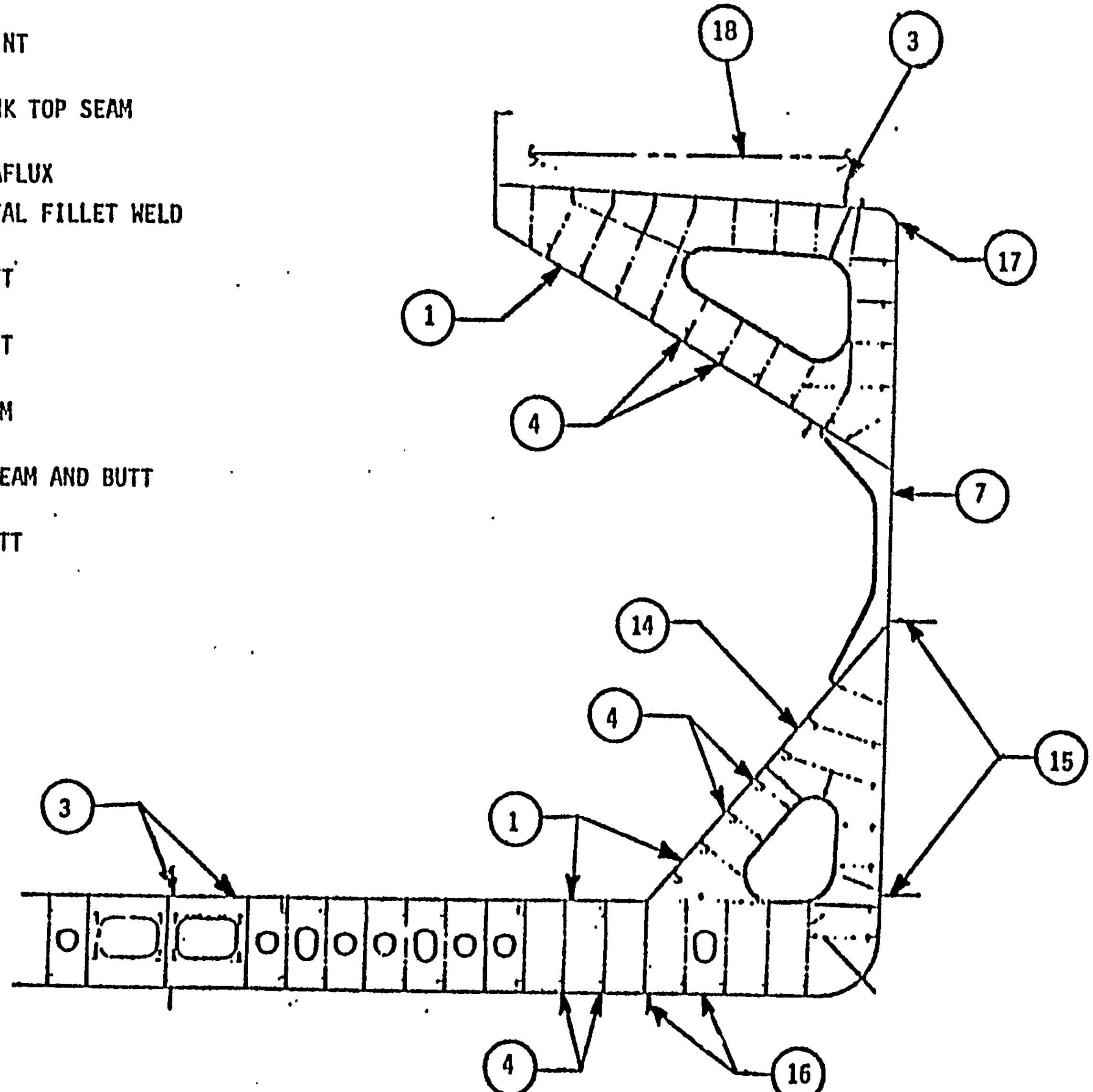


FIGURE 1-30

TABLE Tl-6

AUTOMATIC WELDING IN MODERNIZED SHIPBUILDING

ITEM	NO.	WELDING MEETHOD	APPLICATION
One-Staled Plate Welding	1	Flux copper backing one-sided submerged arc welding (F.C.B. Process)	Panel block joint on assembly stage
	2	RF-1 Flux one-sided submerged arc welding (RF Process)	Panel block Joint on assembly stage
	3	Flux asbestos backing one-sided submerged arc welding (F.A.B. Process)	Curved part panel block joint on assembly stage bottom shell plate seam & deck late seam Joint on erection stage
Frame Welding on Assembly Stage	4	Twin tandem horizontal fillet welding (T.T.F. Process or line welder)	Horizontal fillet of longitudinal members on panel plate
	5	Fillet bead in the vertical position with gasless arc welding (SA-unit)	Vertical fillet welding between the transverse an longitudinal members
	6	Portable sumberged arc fillet welding (SUBSTAR-1)	Horizontal fillet welding of eggbox & innerstructure
Welding on Work Unit (Erection Stage)	7	Electro gas arc welding with press roller	Butt joint on transverse bulkhead & bottom transverse
	8	Powder plug arc welding (P.P.A. Process) & Contact bar submerged arc welding (CBS Process	Butt joint on longitudinal of side shell & longitudinal bulkhead
	9	One-sided electro gas arc welding (S.E.G. Arc-S Process)	Butt joint on deck transverse web plate

ITEM	NO.	WELDING METHOD	APPLICATION
Welding on Work Unit (Erection	10	Consumable nozzle electro slag welding (C.E.S. Process)	Web plate of cross the
	11	C.E.S. and F.A.B. process by same welding & wire (KOB-FAB Process)	Horizontal Girder
	12	Semi-automatic CO_2 welder	Face plate of cross tie
	13		Web plate of side longitudianl face plate of cross tie
Others on Erection Stage	14	Electro as arc welding	Butt joint on side shell & longitudinal bulkhead
	15		Seam joint on side shell plate
	16		Seam & butt joint on bottom shell plate
	17		Butt joint on round gunnel part
	18	Consumable nozzle electro slag welding (C.E.S. Process)	Butt joint on deck longitudinal, lower longitudinal bulkhead & engine girder
	19	Twin electrode type consumable nozzle electro slag welding (K0B-0L Process)	Butt joint on bottom longitudinal

to four times faster in arc time than vertical upward. This method is applicable to welding at the sub-assembly, assembly and erection stages.

One-Sided Welding

IHI utilizes the one-sided welding method in various applications of the assembly and erection stages. The processes utilized include F.C.B. (Flux Core Backing), F.A.B. (Flux Asbestos Backing), R.F. (RF-1 Flux), and $C0_2$ one-sided welding.

The one-sided welding method utilizes backing strips that function similarly in principle but differently in design which allow the welding bead to join both plates with the application of welding on one side only. One-sided welding offers the obvious advantages of elimination of welding on the reverse side of the plates, elimination of plate turnover and handling and less overhead space required for this turnover. Fewer cranes ar more conveyors can thus be used for more efficient and productive work.

Other Auto/Semi-Auto Welding Methods

The submerged-arc welding method is a highly efficient welding method with large heat input and is most widely applied to a straight welding line. This method is most commonly utilized to weld flat butt joints at the sub-assembly and assembly stages.

$C0_2$ gas semi-automatic arc welding is performed at IHI using standard $C0_2$ welding equipment. $C0_2$ arc welding methods are utilized in one-sided and two-sided welding applications.

Electro-gas welding is a form of $C0_2$ gas arc welding used on the vertical butt joints of side shells and bulkheads. The welding equipment is lifted by a chain block hanging on top of the butt joint. The welding operator ascends the side of the vessel in an automatically driven gondola, progressing at the speed of his welding. The weld metal is applied in the joint using water cooled sliding copper shoes.

Gravity welding is a semi-automatic welding method which utilizes natural gravity in the welding process. It is primarily applicable to horizontal fillet welds in the assembly or sub-assembly stages.

The gravity welding unit is a simple structure designed to hold the electrode at the proper drag angle and proper electrode angle-to-joint posture.

The amount of automatic welding applied to hull steel construction on the different types of ships built at IHI is specified in Table T1-7. The ratio of automatic welding to manual welding for the F-32 ships is given as follows:

Sub-assembly 66.0%

Assembly 42.7%

Erection 11.9%

Total Hull 44.4%

IHI believes in a pre-determined welding sequence that is strictly. adhered to in the construction process. The welding sequence proposed by IHI for the bulkers at assembly and erection is illustrated in Figures 1-31 and 1-32.

Pipe welding equipment available at the IHI-Aioi shipyard includes:

Machine	Capacity	Quantity
NC 4-point welder	2-1/2"	1
NC 2-point welder	2-1/2"	1
CO_2 Gas shield arc welder	300A	28
CO_2 Gas shield arc welder	500A	5

TABLE T1-7

AUTO-WELDING RATIO IN IHI'S AIOI SHIPYARD (EXCLUDING SUBCONTRACTING)

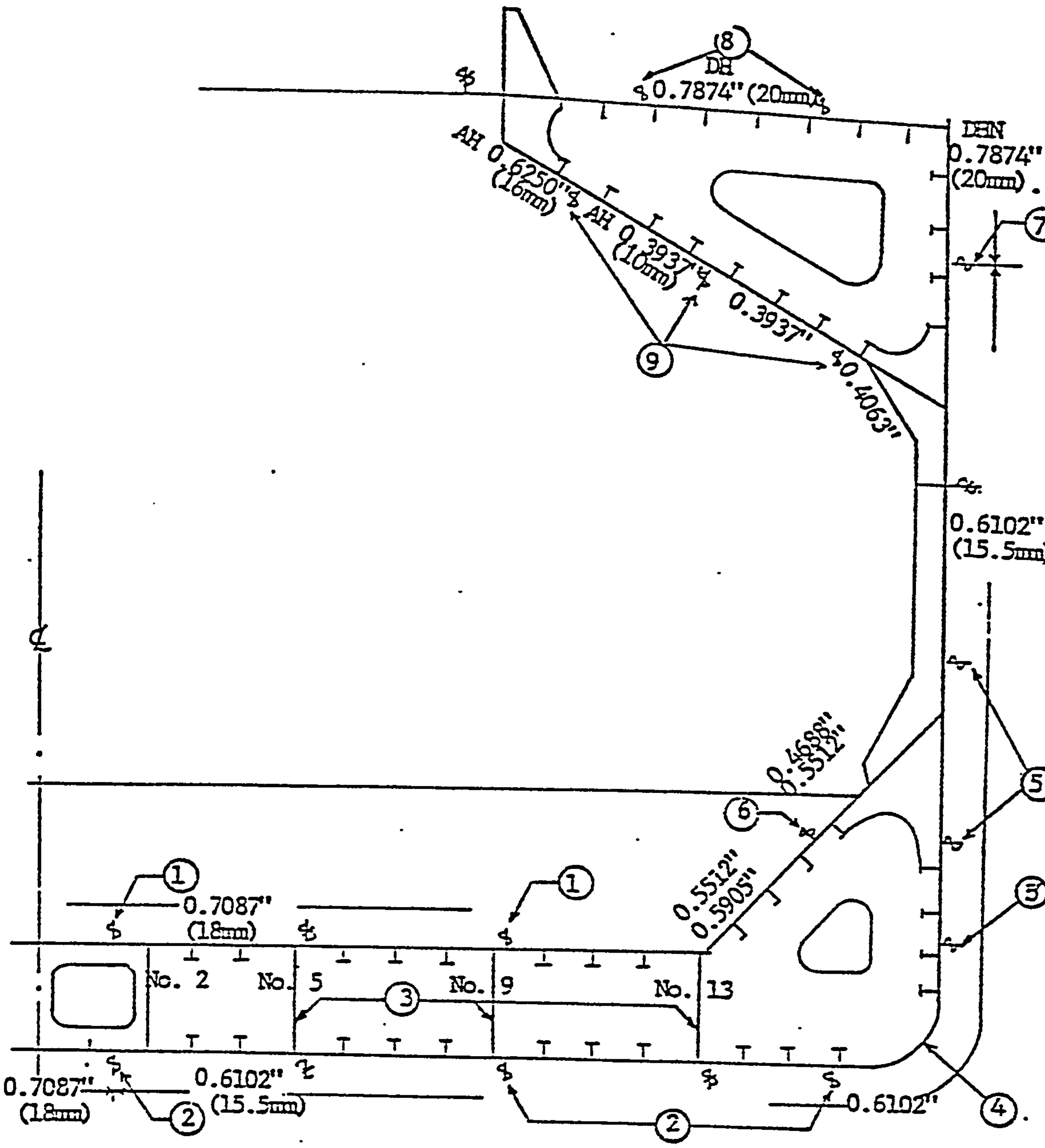
Type of Ship	Hull Steel		No. of Units	Sub-Assembly				Assembly				Erection				Total Hull Steel			
	Total	H.T.		Auto-Welding	Manual Welding	Sub Total	Ratio	Ratio	Manual Welding	Sub Total	Ratio	Auto Welding	Manual Welding	Sub Total	Ratio	Auto Welding	Manual Welding	Total	Ratio
	)	(T)		(H)	(H)	(H)	(%)	(H)	(H)	(H)	(%)	(H)	(H)	(H)	(%)	(H)	(H)	(H)	(%)
						(22.5)		4,223	90,404	(66.8)	4.5			(10.7)		26,773	114,867		18.9
Future - 32	5,432	472.3	114			31,923				94,627		1,800	13,290	15,090	11.9			141,640	
				20,750	11,173		65	(G) 36,161	54,243		42.7					62,934	78,706		44.4
						(24.7)		3,743	67,081	(65.3)	5.3			(10.0)		22,653	85,706		20.9
Friend Ship	4,138		66			26,715				70,824		1,545	9,275	10,820	14.3			108,359	
				17,365	9,350		65	(G) 26,832	40,249		43.2					49,485	58,874		45.7
						(25.3)		2,411	57,108	(64.7)	4.0			(10.0)		18,475	73,568		20.0
Freedom	2,692		72			23,294				59,519		923	8,307	9,230	10.0			92,043	
				15,141	8,153		65	(G) 22,843	34,265		42.4					41,318	50,725		44.9
						(27.1)		2,393	51,881	(64.7)	4.4			(8.2)		17,851	66,039		21.3
Freedom - II	2,840		54			22,720				54,274		690	6,206	6,896	10.0			83,300	
				14,768	7,952		65	(G) 20,752	31,129		38.2					38,603	45,287		46.0
						(28.6)		7,674	111,243	(61.7)	6.5			(9.8)		38,110	154,761		19.8
60,000 Tanker	8,067	1,753.2	153			55,111				118,917		2,881	15,963	18,844	15.3			192,871	
				27,555	27,555		50	(G) 44,497	66,746		43.9					82,607	110,264		42.8
						(28.0)		4,938	128,484	(59.0)	3.7			(13.0)		31,120	195,073		13.8
Container (1240)	10,926		223			63,271				133,422		874	28,620	29,500	3.0			226,193	
				25,308	37,963		40	(G) 38,545	89,939		32.6					69,665	156,528		30.8
						26%				64%				10%					19.1
																			42.4

NOTE: RATIO = $\frac{\text{Welding Length of Auto, Semi-Auto and Gravity}}{\text{Total Welding Length}} \times 100$

(1) Sub-Assembly : including gravity welding

(2) Assembly : upper not including gravity welding, lower including gravity welding, (G) : Welding Length of Gravity Welding

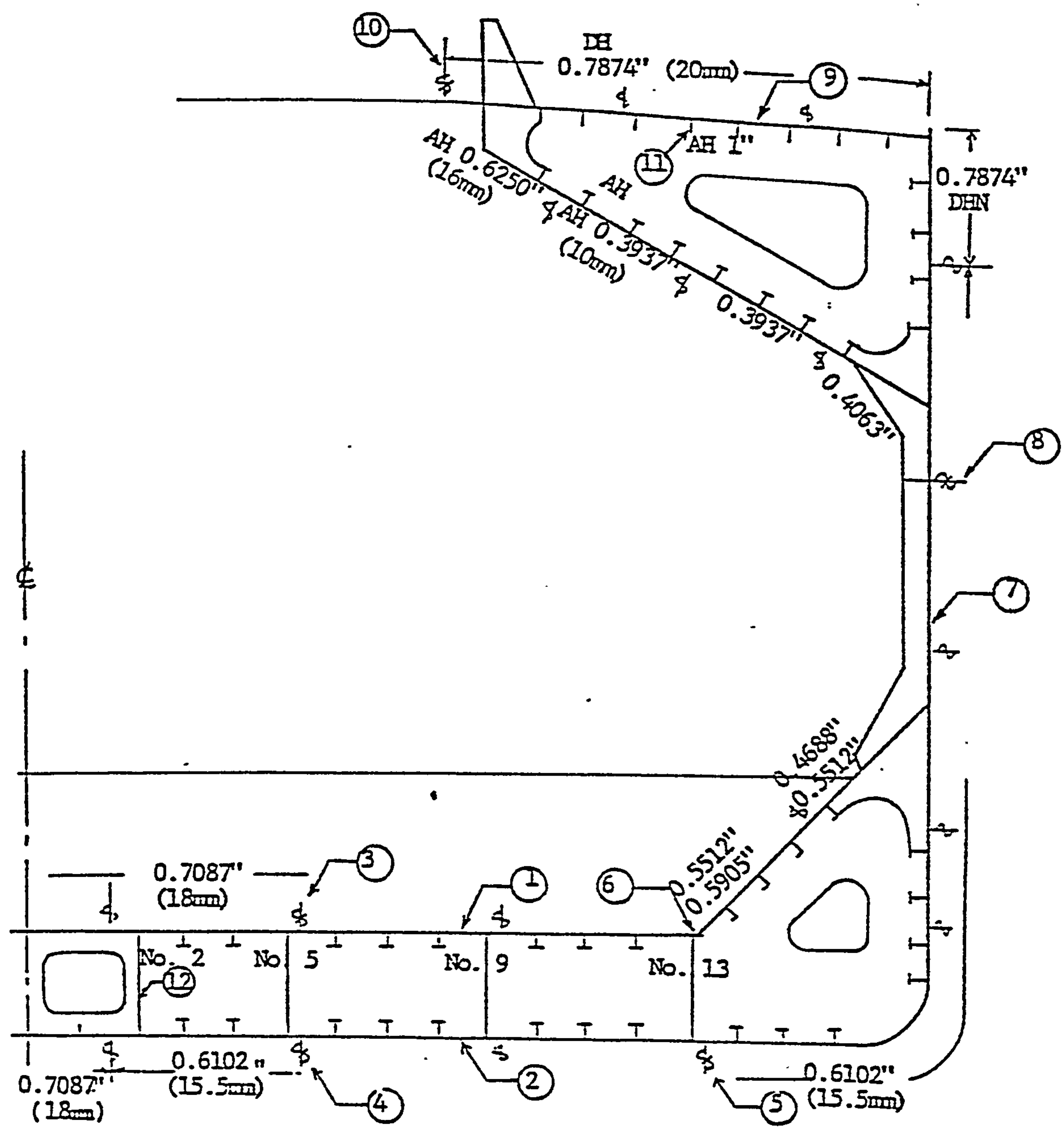
WELD SEQUENCE - ASSEMBLY STAGE



MIDSHIP SECTION

FIGURE 1-31

WELD SEQUENCE - ERECTION STAGE



MIDSHIP SECTION

FIGURE 1-32

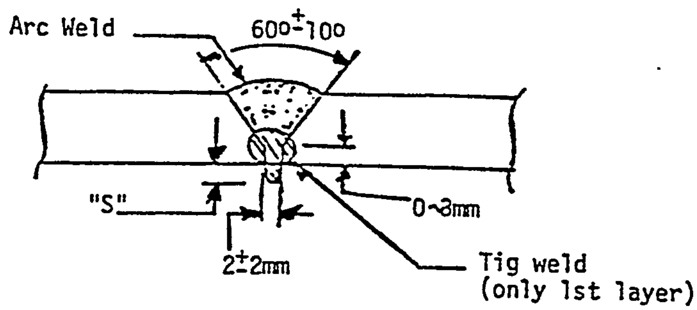
Machine	Capacity	Quantity
DC Tungsten inert-gas welder	200A	4
DC Tungsten inert-gas welder	500A	1
AC Shield metal arc welder	200A	7
AC Shield metal arc welder	300A	4
AC Shield metal arc welder	400A	6
AC Shield metal arc welder	500A	10

TIG welding is principally applied to pipe finished in accordance with Grades A and B and mostly arc welding to pipe finished to Grade C. The butt welding method for TIG welding is illustrated in Figure 1-33, with a chart of maximum allowable values (metric) for height of the inside welding bead "s". Figure 1-34 provides illustration of the butt welding method of arc welding and a table of metric gap values.

JIGS AND FIXTURES

IHI has developed innumerable jigs and fixtures for use throughout the shipyard. Livingston has adopted some of the major jigs, such as the adjustable pin jig system for curved unit assembly, as well as some of the smaller jigs. The jigs and fixtures used at IHI are too numerous to list. Naturally, a number of these are designed to complement the IHI facilities and methods of operation and may not apply elsewhere.

Some of the jigs currently in use have been illustrated by sketches, including some made by Livingston with minor modification. A composite of these sketches of jigs and fixtures is provided on the following pages as being representation of typical jigs used at IHI.



Dimension ; mm

Pipe grade	Nominal dia	"S" (Max)	
A GRADE	All dia.	All around	2
	15+ 25+	Partial	2
	40+ above	Partial	4
B GRADE	15+, 25+	All around	3
	40+ above	All around	3
	15+ 25+	Partial	3
	40+ ~ 65+	Partial	4
	80+ above	Partial	5

BUTT WELDING METHOD - TIG WELDING

FIGURE 1-33

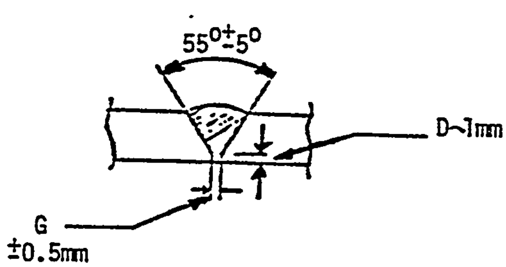


Table of Gap. (unit: mm)

Thick. \ Nom. Dia.	15	20	25	40	50	65	80	100	125	150	200	250	300	350 & above
SGP	G = 1.0	G = 1.0	G = 1.0	G = 1.0	G = 1.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0
Sch 40	G = 1.0	G = 1.0	G = 1.0	G = 1.0	G = 1.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0
Sch 80	G = 1.0	G = 1.0	G = 2.0	G = 2.0	G = 2.0	G = 2.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0
Sch 120	G = 1.0	G = 1.0	G = 2.0	G = 2.0	G = 2.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0	G = 3.0

BUTT WELDING METHOD - ARC WELDING

FIGURE 1-34

NUMBER	COMPANY	DESCRIPTION	USE
Fig. 1-35	IHI	Plate Positioner	Positions plate on the conveyor leading to the shot blast facility.
Fig. 1-36	IHI	Flat Bar Setting Jig	Positions flat bar eliminating tack welding.
Fig. 1-37	LSCo	Tee Support	Supports T-bar at the setting stage on panel line.
Fig. 1-38	LSCo	Alignment Jig	Aligns face plate to eliminate a welded piece.
Fig. 1-39	IHI	Parallel Check Device	Checks plates for parallel to Planer Rail.
Fig. 1-40	IHI	Gas Cutter Stopper	Self-stopping mechanism for gas cutting machine.
Fig. 1-41	IHI	Angle Lifting Hook	Clamp for lifting angles.
Fig. 1-42	IHI	Tee Lifting Hook	Clamp for lifting T-bar.
Fig. 1-43	IHI	Unit Lifting Hook	Hook to lift assembled units by plating through existing holes.
Fig. 1-44	IHI	Hole Cutter-Shell Plate	Cuts circular holes in curved shell plate using gas cutter.
Fig. 1-45	IHI	Hole Cutter - Suction Box	Cuts circular holes in Sea Water Suction Box using gas cutter.
Fig. 1-46	IHI	Roller with Guides	Portable roller bender used with a bending guide mounted on the upper roller.
Fig. 1-47	IHI	Reamer Jig	Reamer bolt squeezing jig used to eliminate awkward work in narrow spaces.
Fig. 1-48	IHI	Bolt Alignment Jig	Tapered alignment jig used for a reamer bolt on an intermediate shaft coupling.

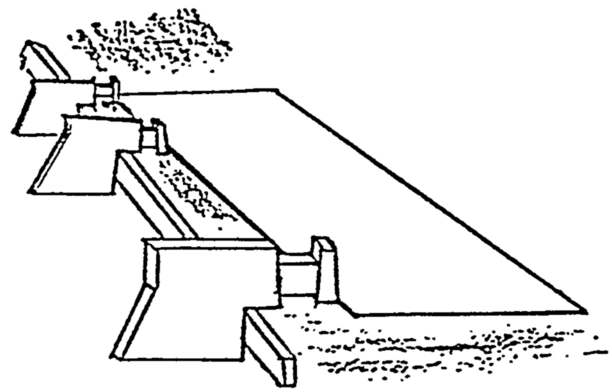


FIGURE 1-35

IHI: Plate Positioner

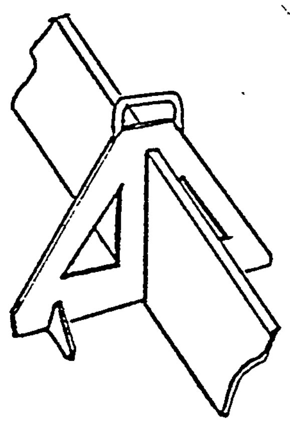


FIGURE 1-36

IHI: Flat Bar Setting Jig

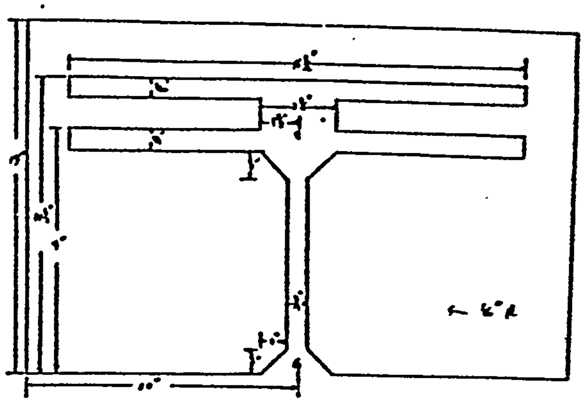


FIGURE 1-37

LSCo: Tee Support

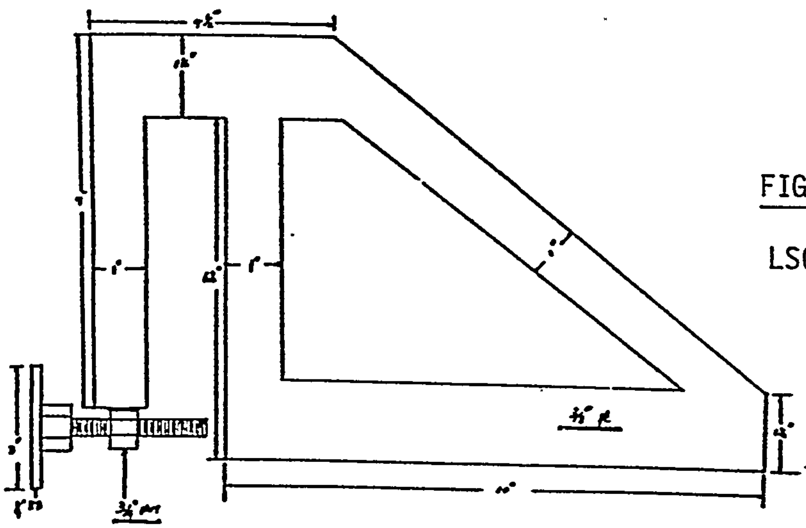


FIGURE 1-38

LSCo: Alignment Jig

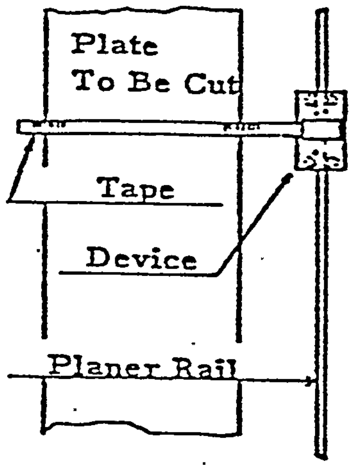


FIGURE 1-39

IHI: Parallel Check Device

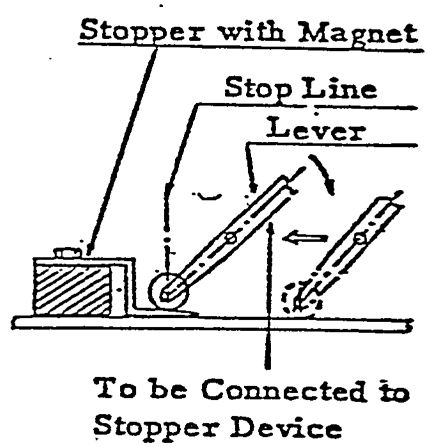


FIGURE 1-40

IHI: Gas Cutter Stopper

FIGURE 1-41

IHI: Angle Lifting Hook

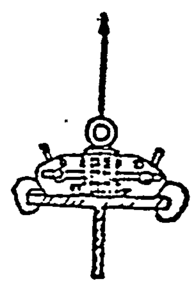


FIGURE 1-42

IHI: Tee Lifting Hook

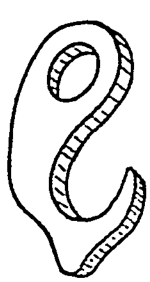


FIGURE 1-43

IHI: Unit Lifting Hook

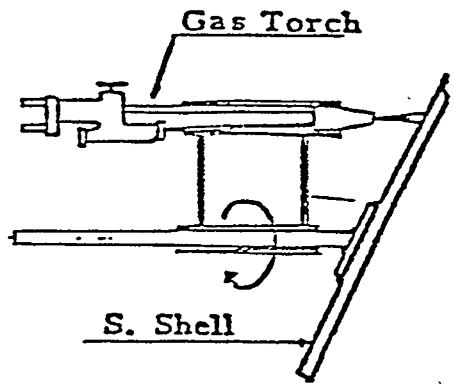


FIGURE 1-44

IHI: Hole Cutter - Shell Plate

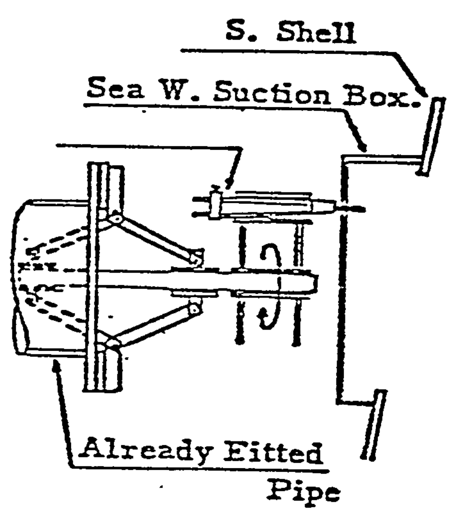


FIGURE 1-45

IHI: Hole Cutter - Suction Box

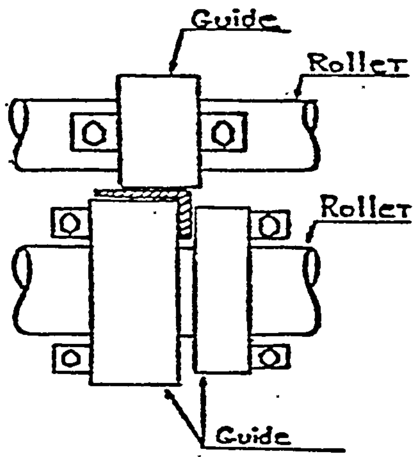


FIGURE 1-46

IHI: Roller with Guides

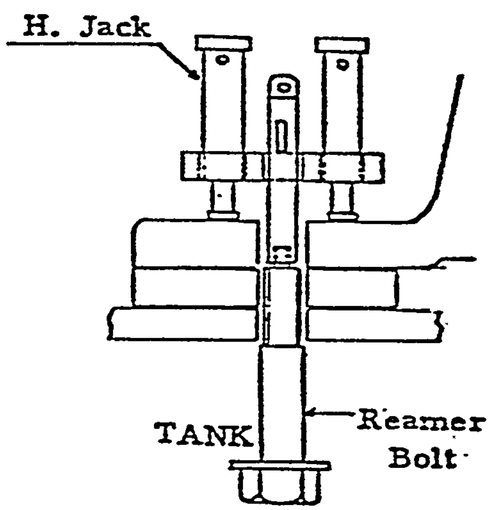


FIGURE 1-47

IHI: Reamer Jig

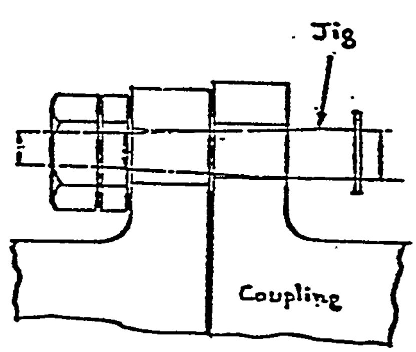


FIGURE 1-48

IHI: Bolt Alignment Jig

FACILITY IMPROVEMENT PLAN

The Livingston Shipbuilding Company Facility Capacity and Capability Study was conducted in July, 1979, under Sub-task 4.1 of the TTP. This study served as a baseline in the evaluation of Livingston facilities for future improvements.

FACILITY INFORMATION - LSCo AND IHI

The Livingston facility at Orange began building steel vessels in 1933. Since then over 700 steel vessels of all types have been constructed. This includes 163 vessels for the offshore industry, 167 vessels for the U. S. Government, and 372 commercial vessels.

The bulk carriers presently under construction are a modified design of IHI's Future-32 vessel. The largest ships ever built at Livingston, they represent Livingston's first major commercial vessels. Differences in facilities, lifting capabilities, methods and other factors result in different construction techniques between the LSCo and IHI shipyards.

The Aioi shipyard at IHI is considered to be comparable to a medium-sized American shipyard. A comparison of IHI and Livingston facilities was undertaken and some of the results are shown below:

Facilities at the IHI-Aioi shipyard include the following:

Building Dock #l:
180,000 DWT Capacity
Crane Capacity: 2 x 200 ton
2 x 80 ton

Building Berth #3:
164,000 DWT Capacity
Crane Capacity: 2 x 120 ton
2 x 80 ton

Shipbuilding Capacity: 8,000 tons per month or
12 F-32 ships per year

Ground Area: 635,034 m^2 (6,835,673 ft^2)

Building Area: 103,332 m^2 (l,112,293 ft^2)

LSCo MARKET PROJECTIONS

At the time Livingston negotiated its five-ship bulker contract in 1978, the future market for the company's business was projected as follows:

45 per cent Bulkers or Tankers

30 per cent Jack-up Rigs

25 per cent Ship Repair

Since that time, demand for jack-up rigs has increased significantly, and strategy was revised in 1980 to reflect this shift in market conditions, to the following breakdown:

30 per cent Bulkers or Tankers

45 per cent Jack-up Rigs

25 per cent Ship Repair

Current business at Livingston includes five jack-up rigs (one launched, one under construction three not yet started), and the bulker contracts (one launched, two under construction, and the remaining two optional vessels in the original contract having been canceled). Negotiations are underway for at least two more jack-up orders and two bulk-container ships.

The comparison between IHI and Livingston shipyards illustrates the differences in their markets and facilities. The approach taken in the Livingston Facility Study was ,to. determine those .improvements suggested by the IHI consultants that would benefit Livingston. With the explanation of the methodology of this facility study, an analysis of the Facility Study is now appropriate.

The IHI facilities were analyzed for comparison with LSCo facilities considering the throughput rates of each area. From a facility standpoint, IHI is highly productive due to a large ratio of enclosed areas, automated equipment, efficient layouts, and high equipment utilization, among other factors.

As a result of analysis of IHI facilities, a review of IHI recommendations, and projected requirements for LSCo throughput rates, a number of suggested improvements were made in the Sub-task 4.1 Final Report. These recommendations, and the actions taken up to the present time, can be summarized as follows:

1) Install an N/C Drafting Machine (agreed to in principle).
2) Install an N/C Burning Machine with plasma cutting torches (completed).
3) Purchase a 1:1 Optical Tracing Machine (completed).
4) Establish a Flame Bending Area, with work tables (completed).
5) Install a Panel Line operation (completed).
6) Install curved unit assembly jigs, or “pin jigs” (partially adopted).
7) Increase the amount of Assembly Areas (area increased by 40,000 ft^2).
8) Build scaffolding for repeated use in bulker construction (some specifically designed scaffolding was used, but in other cases universal-type scaffold was rented).
9) Greater use of automatic welding equipment (LSCo has implemented one-sided welding in the Panel Line and this program is being expanded to Assembly Areas. Also, the use of vertical downhand welding rods was implemented).
10) Build new pipe shop (agreed to in principle).
11) Install automatic pipe bending machine (bought and installed 3“ capacity machine).
12) Build pipe pallets and arrange storage for fabricated pipe in pallets (30 pallets built and storage area allocated).

Naturally, these improvements are considered to be of greatest need and, as described above, many have already been implemented. There are a number of other desirable improvements which would be beneficial to shipyard efficiency and productivity. These are reviewed below for each area with the thought in mind that some improvements will be as much as five years away. Those improvements affecting the bulker program, in turn relating more directly to TTP items, are emphasized.

REVIEW OF AREAS FOR IMPROVEMENT

Table TI-8 lists desirable improvements throughout the shipyard which have not already been implemented. Each improvement has been categorized as being of high, medium or low priority, as determined by its relative significance compared to other needed improvements. These terms are loosely defined as follows:

High Priority - Immediate benefit to be gained, in an area with relatively significant impact to other shipyard activity.

Medium Priority - Substantial benefit foreseen, in a less significant area.

Low Priority - No particular urgency, area not presently ready for improvement to achieve maximum benefits, or the area has less effect on operations as a whole.

Those improvements designated as high priority show up in the first or second year of the long range plan. The medium priority improvements are spread through the second to fourth year, while the low priority items are planned for the fourth or fifth year.

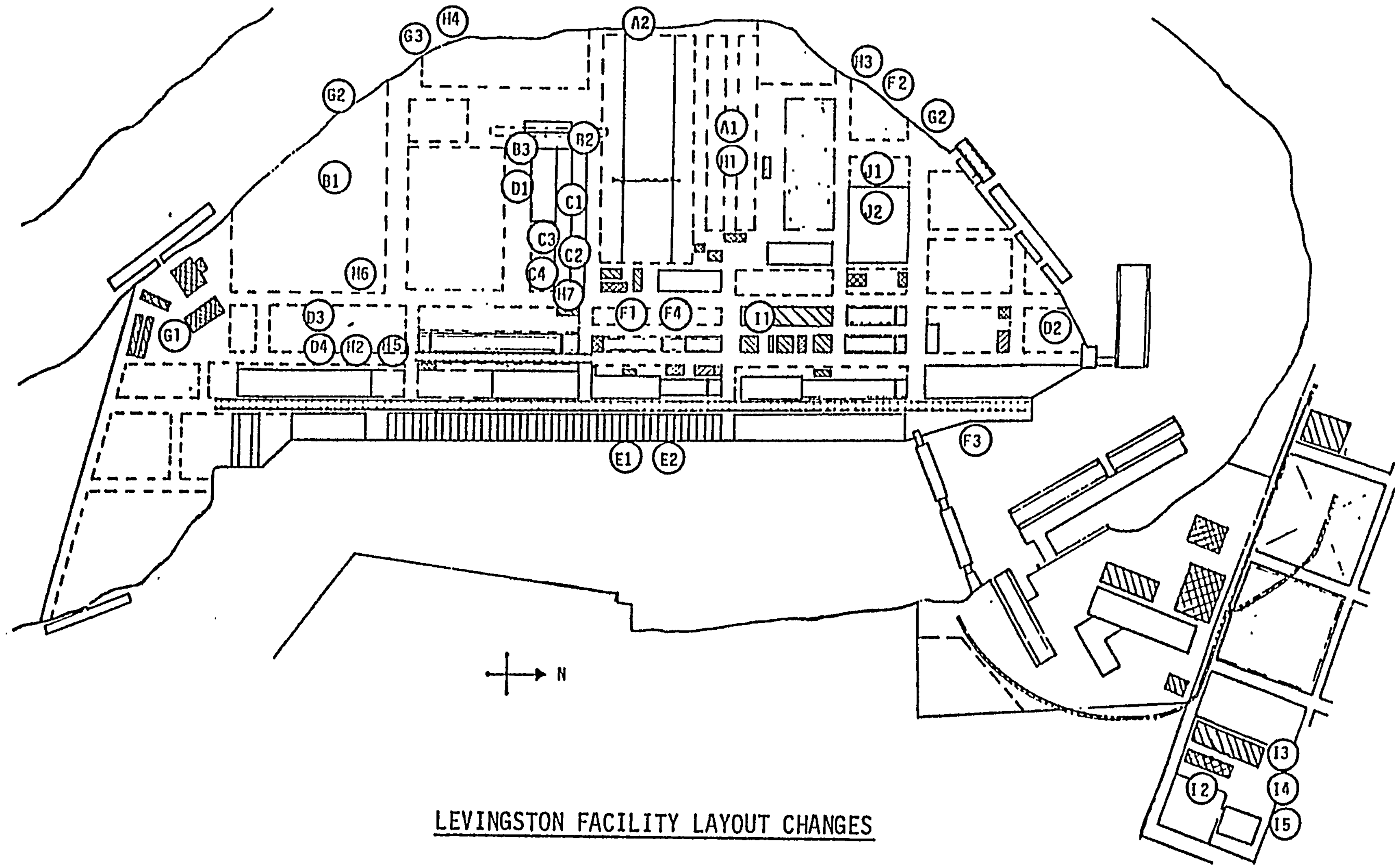
Figure 1-49 is a layout of Levingston's facilities marked with the codings described on Table T1-8 to denote the location of improvements planned for the Livingston facility. Table T1-8 also specifies the main reason for each improvement in explanation of the benefits it would provide to the shipyard.

TABLE T1-8

PROPOSED IMPROVEMENTS

AREA	IMPROVEMENT	REASON FOR CHANGE	PRIORITY	COST*	CODE
A. STEEL STORAGE	1. CRANE TO HANDLE STRUCTURAL STEEL	MORE EFFICIENT UNLOADING & HANDLING	MEDIUM	50 - 200	A1
	2. EXTENSION OF MATERIAL HANDLING CRANE TO RIVER BANK	ALLOWS UNLOADING FROM BARGES	MEDIUM	10 - 50	A2
B. STEEL PREP-ARATION	1. INSTALL ENCLOSED ABRASIVE BLAST-ING FACILITY	POLLUTION CONTROL, ATMOSPHERIC CONTROL	MEDIUM	500+	B1
	2. INSTALL VERTICAL PLATE STORAGE RACKS	MORE EFFICIENT HANDLING & STORAGE	MEDIUM	10 - 50	B2
	3. REPLACE VERTICAL SHOT BLAST WITH HORIZONTAL TYPE	BETTER HANDLING OF MATERIALS	LOW	500+	B3
C. FABRICA-TION SHOPS	1. ADD CAB-OPERATED CRANE IN SHOP 5	ADDED LIFTING CAPACITY	LOW	50 - 200	C1
	2. ADD 3000 TON VERTICAL PRESS	ADDED BENDING CAPACITY & VERSATILITY	HIGH	500+	C2
	3. EXTEND SHOP 6	ORGANIZED MATERIAL FLOW; WEATHER PROTECTION	HIGH	50 - 200	C3
	4. ADD 10 TON CRANE - SHOP 6 EXTENSION	ADDED LIFTING CAPACITY	MEDIUM	50 - 200	C4
D. ASSEMBLY AREAS	1. BUILD NEW SHOP 7 FOR SUB-ASSEMBLIES	ORGANIZED MATERIAL FLOW: WEATHER PROTECTION	LOW	500+	D1
	2. DECK HOUSE ASSEMBLY AREA	ADDITIONAL SPACE & CRANE ACCESS	LOW	50 - 200	D2
	3. EXPAND SLAB AREAS & BUFFER STORAGE	INCREASED ASSEMBLY & STORAGE CAPACITY	MEDIUM	200 - 500	D3
	4. EXTEND GANTRY RAILS (2ND ST.)	TO SERVICE EXPANDED ASSEMBLY AREAS	HIGH	50 - 200	D4
E. ERECTION AREAS	1. DRIVE SHEET PILING AT LAUNCH-WAY	TO PREVENT EROSION OF LAUNCHWAY	MEDIUM	200 - 500	E1
	2. EXTEND SIDE LAUNCHWAYS INTO RIVER	INCREASE LOAD CAPACITY & DECREASE RISK OF VESSEL DAMAGE DURING LAUNCH	LOW	50 - 200	E2
F. OUTFIT-TING AREAS	1. NEW PIPE SHOP	BETTER MATERIAL FLOW & INCREASED PRE-OUTFITTING	HIGH	50 - 200	F1
	2. DRIVE SHEET PILING FOR OUTFIT-TING DOCK	TO EXTEND WORKING DISTANCE	MEDIUM	500+	F2
	3. REVISE POWER LINE OUTLAY	REDUCED CHANCE OF POWER OUTAGE	LOW	10 - 50	F3
	4. PURCHASE AUTOMATIC PIPE FABRI-CATION EQUIPMENT	INCREASED PRODUCTIVITY	LOW	10 - 50	F4
G. SHIP REPAIR	1. UPGRADE GAS-FREE PLANT	CONTINUED COMPLIANCE WITH STRICTER REGULATIONS	HIGH	500+	G1
	2. DRIVE SHEET PILING FOR REPAIR DOCKS	RELOCATE REPAIR	MEDIUM	500+	G2
	3. RELOCATE REPAIR FACILITIES	REDUCE COMMUNITY EXPOSURE TO AIR POLLUTION & LESS CONGESTION	MEDIUM	200 - 500	G3
H. MATERIAL HANDLING	1. CRANE TO HANDLE STRUCTURAL STEEL	(SEE A1 ABOVE)	-	-	A1
	2. EXTEND GANTRY RAILS	(SEE D4 ABOVE)	-	-	D4
	3. ADD RAILS, RELOCATE GANTRY FOR NEW O/F DOCK	REDUCED USE OF RIVER CRANES	LOW	200 - 500	H3
	4. ADD RAILS & GANTRY FOR RELOCATED REPAIR DOCK	REDUCED USE OF RIVER CRANES	LOW	200 - 500	H4
	5. STREET IMPROVEMENTS	BETTER VEHICLE TRAVEL	HIGH	50 - 200	H5
	6. PRIME MOVER FOR TRANSPORTER	TO PROVIDE ADEQUATE POWER	HIGH	10 - 50	H6
	7. NEW FORKLIFT FOR SHOP 5	TO INCREASE TRANSPORTING CAPABILITIES	HIGH	10 - 50	H7
I. ENGINEER-ING SUPPORT FACILI-TIES	1. PURCHASE N/C DRAFTING MACHINE FOR MOLD LOFT	DECREASED MANPOWER	HIGH	50 - 200	I1
	2. ADDITIONAL OFFICE BLDG SPACE	CONSOLIDATE PERSONNEL	HIGH	50 - 200	I2
	3. PLOTTER & ASSOC. MACHINE TO PRODUCE WORKING DRAWINGS BY COMPUTER	AUTOMATED DRAFTING	LOW	50 - 200	I3
	4. GRAPHIC SYSTEM FOR 3D DRAWINGS	AUTOMATED DRAFTING	LOW	10 - 50	I4
	5. C.A.D. SYSTEM TO PRODUCE DRAWINGS	AUTOMATED DRAFTING	LOW	50 - 200	I5
J. WARE-HOUSING	1. INCREASE COVERED WHSE FACILITIES FOR STOCK	ADDITIONAL COVERED STORAGE SPACE	HIGH	50 - 200	J1
	2. BUILD/PURCHASE STORAGE PALLETS	BETTER MATERIAL HANDLING	MEDIUM	10 - 50	J2

COST RANGES ($000): 10 - 50 50 - 200 200 - 500 500+



LEVINGSTON FACILITY LAYOUT CHANGES

FIGURE 1-49

As a result of examination of each of these areas, and analysis of the effect of the proposed changes on other areas, the value of long range planning becomes apparent. In some cases, a change in one area conflicts with the improvement plans in another area. In other cases, a proposal in one area can complement that in another, but a modification of the original proposal may be necessary. This observation can be illustrated by examining the reasoning for changes in each area.

Steel Storage

It would be advantageous to Livingston to have the capability of unloading plates and structural from barges at the material storage yard.

Steel Preparation,

The two main problems needing correction in this area, and the proposed solution, include:

1) Problem: Sandblasting in open areas, creating dust and air pollution.

Proposal: Install enclosed blasting facility.

2) Problem: Plates are processed in blast and coat operations in a vertical position, but are stored horizontally before and after this operation.

Proposal A: Install vertical plate storage racks.

Proposal B: Replace the vertical shot blast facility with a horizontal type.

Fabrication Shops

Additional shop space, material handling capability, and plate forming capacity are desired.

Assembly

Additional shop space is desired to enclose assembly operations. A new location for assembly of deck houses is directly related to the plans for a future outfitting dock. Additional fabrication and assembly slabs are desired near the erection sites.

Erection Areas

Improvement to the side launchways is desirable for maintenance of its present condition and for increasing the capacity of its load-supporting capabilities for heavier ships.

Outfitting Areas

Improvements in outfitting facilities emphasize automated pipe fabrication and increased dock space. A new pipe shop with an orderly lay out and automated equipment is planned to increase pipe fabrication productivity.

Material Handling

Gantry service is planned as a supplement to expansions at the outfitting docks, repair docks, and unit assembly areas.

Engineering Facilities

The proposals for improvements in Engineering facilities relate mostly to requests for automated equipment. The N/C drafting machine is a high priority item. Other proposals relate to computer-aided design equipment.

Warehousing

Livingston presently faces a shortage of covered warehouse space for its current business. Therefore, additional storage space is a high priority item. Also, plans are being formulated to build storage pallets for warehouse use similar to the pallets used for fabricated pipe storage.

LONG RANGE PLAN

This analysis of proposed improvements was summarized in Table T1-8. Subsequent to analyzing these desired changes, a chart giving advantages and disadvantages of each proposal was developed and is shown as Table T1-9. The purpose of this exercise is two-fold:

TABLE T1-9 EFFECTS OF PROPOSED IMPROVEMENTS

LEGEND:
- XX SIGNIFICANT DEGREE
- X MODERATE DEGREE
- (blank) NOT APPLICABLE

PROPOSED IMPROVEMENT	ADVANTAGES: INCREASED PRODUCTIVITY	FEWER DELAYS	MORE FLEXIBILITY	BETTER QUALITY	IMPROVED CONTROL	EASIER PLANNING	SAFER CONDITIONS	FEWER PERSONNEL	REDUCED CONGESTION	IMPROVED MAT'L FLOW	BETTER MAT'L HANDLING	EXPANDS AREA	IMPROVED MAINTAINABILITY	RAPID PAYBACK	WEATHER PROTECTION	RELIEVES BOTTLENECK	POLLUTION CONTROL	EASIER STANDARDIZATION	REPLACES OBSOLETE EQUIPMENT	ELIMINATES AN OPERATION	UPGRADES APPEARANCE	AUTOMATES OPERATION	EXTENSION OF OTHER PROJECT	DISADVANTAGES: CAPITAL INVESTMENT	SLOW PAYBACK	ADDITIONAL PERSONNEL	INCREASED MAINTENANCE	INCREASED OPERATING COST	TRAINING COSTS	LAYOUT CHANGE REQUIRED	INCREASED MAT'L HANDLING
A. STEEL STORAGE																															
1. CRANE FOR STRUCTURALS	X	X			XX	X	X		XX	XX	XX	X						X		X	X	X		XX	X		X			XX	
2. EXTEND STORAGE YARD			X						X	X	XX	X												X	XX					X	
B. STEEL PREPARATION																															
1. ENCLOSED BLAST HOUSE	X	XX	X	X	XX	X	XX		X	X	X				XX		XX	X	X		XX	X		XX	XX		X	XX		X	
2. VERTICAL PLATE RACKS		X			X		X		XX		XX					X		X			X			X	XX					X	
3. HORIZONTAL SHOT BLAST	X										XX							X		X				XX	XX				X	X	
C. FABRICATION SHOPS																															
1. CRANE - SHOP 5	X	XX							XX	X	XX					X		X			X			XX	X	X	X	X			
2. 3000 TON VERTICAL PRESS	XX	X	XX		X	X			XX	XX				X		XX		X	X			X		XX		X	XX	X	X		
3. EXTEND SHOP 6	XX	XX	X		XX	XX	X		X	XX	X			X	XX			XX			XX	X	X	XX				XX		X	
4. CRANE - SHOP 6	X	XX							XX	X	XX			X				X			X			XX			X	X			
D. ASSEMBLY AREAS																															
1. ADD SHOP 7 - S/A'S	XX	X	X		XX	XX	X	X	XX	XX	XX			X	XX			XX			XX	X		XX		X		XX		XX	
2. DECK HOUSE ASSY AREA	X	X				X					XX	X									X			X	XX					X	
3. EXPAND SLABS		XX	X		X	XX			XX	XX		XX		X		X		X			X			X						X	X
4. EXTEND GANTRY RAILS	XX	X	X			X					XX	X		X		X		X					X	X		X	X			X	X
E. ERECTION AREAS																															
1. SHEET PILING - LAUNCHWAY													XX						X		X			XX	XX						
2. EXTEND LAUNCHWAYS			X									X												XX	XX						
F. OUTFITTING AREAS																															
1. NEW PIPE SHOP	XX	X	X	X	XX	XX	X	X	X	XX	XX	X		X	XX			XX			X	X		XX			X	X		XX	
2. SHEET PILING - O/F DOCK (SEE H3 BELOW)																							X								
3. POWER LINES		X											XX						X					X	XX						
4. AUTO. PIPE FAB EQUIPMENT	XX	X	XX	XX	XX	XX		X		X			X	X				X	XX			XX	X	X			X	X	X	X	
G. ENVIRONMENTAL & REPAIR																															
1. GAS-FREE PLANT													XX				XX		XX		XX	X		XX	XX		X	XX	X	XX	
2. SHEET PILING - REPAIR DOCKS (SEE H4 BELOW)																							X								
3. RELOCATE REPAIR									XX		X						XX							XX	XX					XX	
H. MATERIAL HANDLING																															
1. CRANE FOR STRUCTURALS (SEE A1 ABOVE)																							X								
2. EXTEND GANTRY RAILS (SEE D4 ABOVE)																							X								
3. GANTRY - O/F DOCK	X	X	X			X			X	X	XX	X									X		X	XX	XX	X	XX	XX	X	X	
4. GANTRY - REPAIR DOCK	X	X	X			X			XX		XX										X		X	XX	XX	X	XX	XX	X	X	
5. STREET IMPROVEMENTS											XX		X								XX			XX	X						
6. HOVER FOR TRANSPORTER											XX		X	X								X		X							
7. FORKLIFT FOR SHOP 5	X	X				X					XX			X		X			X								X				
I. ENGINEERING FACILITIES																															
1. N/C DRAFTER	X		XX	XX	XX	X		XX						XX				X	X	X		X		X			X		X		
2. ADD'L OFFICE SPACE						X			XX			X									X			X	X		X	X			
3. PLOTTER FOR COMPUTER DRAWINGS	X		XX	XX	X	X		X										X	XX	X		XX	X	XX	X		X	X	X	X	
4. GRAPHIC SYSTEM - 3D DRAWINGS	X		X	X		X		X										X	XX	X		XX	X	X	X		X	X	X		
5. C.A.D. SYSTEM FOR DRAWINGS	X		XX	XX	X	XX		X										X	XX	X		XX	X	XX	X		X	X	X		
J. WAREHOUSING																															
1. MORE COVERED WHSE SPACE		X	X		XX	X			XX	X	XX	XX		X	XX			X			XX			XX							
2. STORAGE PALLETS	X	X	X		XX	XX			XX	XX	XX			X				X		X	XX		X	X				X	X	X	

1) To determine the merit of each proposal by weighing its advantages versus its disadvantages.

2) To compare the worth of each proposal relative to the other proposals being considered. This could lead to re-assignment of the priorities of each item as listed in Table T1-8.

Each advantage and disadvantage listed in Table Tl-9 obviously does not carry equal weight. Furthermore, in some cases a single advantage for a particular proposal, such as for “pollution control”, may overshadow all other advantages and disadvantages. The table was accordingly developed to indicate whether those advantages and disadvantages pertain to a given proposal to a significant degree, to a moderate degree, or as not applicable.

The list of items included as advantages and disadvantages are general in nature but are representative of the type of effects resulting from almost any proposed facility improvement.

The Livingston Long Range Plan, shown in bar chart form on Table T1-10, was drawn up following analysis of all data in Tables T1-8 and T1-9 and a numerical analysis. The “group” category as determined by the numerical analysis is included in this table. Completion of this chart included a review of the cost of each proposal within specified ranges as given in Table T1-8. The budget plans can be developed for succeeding years based on these cost ranges and the Long Range Plan. This analysis is summarized in the chart below, which specifies the number of projects adopted during each of the next five years within each of the given cost ranges:

TABLE T1-10

LSCo LONG RANGE PLAN

DESCRIPTION	GROUP*	COST**		FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984	FISCAL YEAR 1985
N/C Drafting Machine	I	50-200						
Additional Covered Warehouse Space	I	50-200						
3000 Ton Vertical Press	I	500+						
Extend Gantry Rails	II	50-200						
Forklift for Shop 5	I	10-50						
Additional Engineering Office	III	50-200						
Expand Assembly Slabs	I	200-500						
Extend Shop 6	I	50-200						
Prime Mover for Transporter	II	10-50						
Street Improvements	III	50-200						
New Pipe Shop	I	50-200						
Sheet Piling for Repair Docks	III	500+						
Sheet Piling for Outfitting Docks	III	500+						
Crane for Shop 6 Extension	II	50-200						
Crane for Structural Storage	II	50-200						
Warehouse Storage Pallets	I	10-50						
Enclosed Abrasive Blast House	II	500+						
Relocate Repair Docks	III	200-500						
Track and Gantry for Outfitting Docks	III	200-500						
Track and Gantry for Relocated Repair Docks	III	200-500						
Add Crane for Shop 5	III	50-200						
Add Shop 7 for Sub-Assemblies	I	500+						
Plotter for Engineering Drawings by Computer	II	50-200						
Automatic Pipe Fabrication Equipment	I	10-50						
Graphic System for 3D Engineering Drawings	II	10-50						
Deck House Assembly Area	II	50-200						
Horizontal Shot Blast Facility	III	500+						
Revised Power Line Outlay	III	10-50						
C.A.D. System for Engineering Drawings	II	50-200						

*Group determined by mathematical analysis.
**Cost Ranges ($000): 10-50 50-200 200-500 500+

NO. PROJECTS PER YEAR

YEAR / CAPITAL ($000)	1	2	3	4	5
10-50	1	1	1	1	1
50-200	4	3	2	2	2
200-500	1	-	1	2	-
500+	1	2	1	1	1
MIN. $	910	1160	810	1010	610
MAX. $	2350	2650	1950	2450	1450

IHI Approach

The method used by IHI to develop a long-range plan is similar in concept to that used by a U. S. shipyard. Formal proposals for major investment items originate with the Section Managers, who submit them to their Department Managers. After making priority selections, the Department Manager submits proposals to the General Superintendent of the shipyard. The proposals are further prioritized for the facility by the General Superintendent and submitted to the Head Office in Tokyo.

A committee meets semi-annually in Tokyo to discuss these major facility requests and to establish a three to five year plan. This plan is subject to review at these meetings. The committee is composed of members of the Facilities, Finance and Production groups. They tour each facility to observe the operations which are being proposed for renewal or improvement; then they review the costs and projected savings associated with the proposals, taking into consideration the previous year's budget, furture market potential, and company financial condition. The committee finally sets priorities for major facility investments and allocates budgets accordingly.

Those improvements requiring minor investment, such as new jigs, welding machines, etc. , are handled separately from major investments. Each Department Manager is given a budget from which each Section Manager may suggest expenditures that would benefit his area. Department Managers issue approval for the expenditures based on need, cost, savings, and priority.

A major distinction from normal U. S. procedure is present, however. At IHI, separate budgets are prepared for two types of facility improvements:

1) Safety or Environmental Facilities
2) Manufacturing Facilities

Those facilities involving safety or environment are given first priority and are reviewed initially by the committee in Tokyo. This includes such items as scaffolding, life nets and pollution control equipment. Other facility improvements are expected to have tangible savings calculated, so that paybacks and returns on investments can be compared. These savings and cost figures are given a follow-up review by the committee to compare the actual with projected figures.

CONCLUSION

The long-range facility plan for Livingston Shipbuilding Company has been developed in accordance with the usual practice of U.S. industry; future markets, machine innovations, government regulations, financial conditions and physical limitations were all considered. Concerning bulker-type ship production Livingston is emphasizing such fundamental items as:

1) Improved material flow
2) Better material handling equipment
3) Enclosed facilities
4) Automated equipment
5) Increased shop space, fabrication areas and buffer storage
6) Additional warehouse space
7) Increased outfitting capabilities
8) Improved pollution control facilities
9) Additional engineering facilities

The Livingston study of Facility Capabilities and Capacity, the improvements suggested by IHI, and the marketing objectives of the company have been considered in developing this long-range plan. The impact of changes as suggested by IHI are evident in the improvements already implemented to date as well as those being considered by Livingston for the next five years.

Long-range planning requires making decisions based on present knowledge to forecast future business directions. Management must be cognizant of the fact that conditions will not change exactly as predicted, but that the long-range plans are based on the best information available at the time the plan is developed. Therefore, it is evident that the long-range plan will require annual updating to take into consideration the unforeseen events that impact the organization's plans for growth. However, the value of long-range planning should be quite apparent in that it specifies the facility modifications and improvements that are required to meet the corporate marketing objectives. Development of a facility plan with corresponding timetables of events will hopefully prevent conflicts in allocations of resources and building of unsatisfactory facilities for the jobs to be done.

This is Livingston's most detailed long-range plan developed over an extended period. The company has an optimistic outlook for future development of the shipbuilding industry and is planning positive steps to meet the forthcoming challenges at Livingston. A great number of improvements have been made since the inception of the Technology Transfer Program two years ago. Many ideas of both Livingston and IHI personnel have been implemented. The successful implementation of these ideas coupled with the enthusiasm for application of new techniques and concepts indicate the acceptance and continued development of long-range plans at Livingston in the years ahead.